SCIENCE EDUCATION

THE SCIENCE MAGAZINE FOR ALL SCIENCE TEACHERS
FORMERLY GENERAL SCIENCE QUARTERLY

The Planning of a State Program in the Teaching of Science

Professionalized Subject-Matter Courses

Pupil Responses to the Concepts of Mechanics

Testing and Learning in Biology

Elementary Science Program in Cleveland Schools

Learning General Science through Projects

Chinese Chemists Name the Elements

Students' Interests in Motion Pictures

Science Knowledge of High School Pupils

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Science Education

Devoted to the Teaching of Science in Elementary Schools,
Junior and Senior High Schools, Colleges and
Teacher Training Institutions

Volume 17 DECEMBER, 1933 Number 4

Factors Influencing the Common Science Knowledge of High School Pupils

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and

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What are the factors which influence a pupil's functional knowledge of common science? Is his functional knowledge directly related to the number of formal science courses taken in high school? How much more do seniors know about common science than freshmen? Do such factors as age, nationality, educational and occupational status of parent, curriculum, have an influence? The purpose of the study here reported was to determine the relation of certain specific factors in the pupil's school and out-of-school environment, to his functional knowledge of common science.

The study was conducted in the Utica Free Academy of Utica, N.Y. In the study were involved 1070 pupils in 40 science classes distributed by subjects as follows: biology, 577; chemistry, 227; physical geography, 43; physics, 223. Data for the 14 factors of the investigation were obtained from school records, questionnaire, and personal interview. Functional knowledge of common science was measured by a multiple re-

sponse test of 50 questions. The test involved everyday situations in common science, and was couched in non-technical language. The test was thus unlike the conventional standardized test in science. A score in any of the well-known standardized science tests depends significantly upon the subject's understanding of technical words, symbols, and definitions. In terms of subject fields the 50 questions of the test used in the present study may be roughly classified as follows: biological, 10; physical, 32; chemical, 5; physiographical 3. The three following questions are illustrative of the 50 questions composing the test.

1. It is easier to swim in salt water than in fresh water because the salt water is: (a) quieter, (b) deeper, (c) denser, (d) invigorating, (e) warmer.
2. A balloon rises because it is: (a) larger, (b) lighter than the air which surrounds it, (c) made of light materials, (d) not anchored, (e) has a wicker basket.
3. The best way to ventilate a room is: (a) lower a window, (b) raise a window, (c) lower one window and raise another, (d) lower one sash and raise the other sash of the same window, (e) raise two windows.

Factor I: Age

Table I
Age-score Distribution

Age	*No. of Pupils*	*Average Score*
12	5	22.50
13	79	23.14
14	240	23.49
15	220	26.03
16	199	30.40
17	163	32.82
18	110	34.75
19	35	34.63
20	10	34.90
21	4	28.00
22	1	37.00
23	2	32.50
26	1	30.00
35	1	37.00

Table I shows that the six-year range, 13-18, includes the great majority of pupils. In this six-year range, a gradual increase in score with age is shown. The more mature pupils have acquired or picked up more knowledge in common science.

FACTOR II: Sex

The average score of 593 boys was 31.87; of 477 girls, 24.05. Boys are far superior to the girls in average score. These data suggest significant problems for secondary education. Have the boys through vicarious experience picked up more knowledge of common science than the girls? Do the girls like science less than the boys? Do the girls consider science less useful than do the boys? In this study, the boys in each science subject excel the girls.

FACTOR III: Curriculum

The average score of 497 pupils enrolled in the scientific curriculum was 31.81; of 573 pupils not enrolled in the scientific curriculum, the average score was 25.41. In terms of this study, specialization of aim as indicated by curriculum selection, has a very definite influence on pupil achievement.

FACTOR IV: Science Courses Passed

TABLE II
RELATION OF SCORE TO AMOUNT OF HIGH SCHOOL SCIENCE PASSED

	No Science	*½ Yr.*	*1 Yr.*	*1½ Yr.*	*2 Yr.*	*2½ Yr.*	*3 Yr.*	*3½ Yr.*	*4 Yr.*
Score	22.60	25.97	30.35	34.27	38.03	39.75	41.00	42.00	45.00

Table II shows the average scores made by pupils who have passed in high school varying amounts of science work. The data reveal a definite positive relationship between scores in the common science test and the amount of science passed in high school.

FACTOR V: School Marks

The composite school marks of each pupil were evaluated, and pupils classified in terms of the general divisions: excellent, good, fair, poor. The respective scores for these groups were: excellent, 34.86; good, 32.41; fair, 29.55; poor, 25.29. The relationship is definite and positive between a pupil's general academic standing and his knowledge of common science as measured by the test used.

FACTOR VI: Membership in Science Club

Science club membership in the physical sciences only was considered. The average score for 82 science club members was 36.05; for 411 non-

members, 33.99. What part of this difference is due severally to cause and effect is not evident. Those with more ability or more interest in science may have become club members; or membership in the science club may have increased the pupils' knowledge of common science.

Factor VII: Workshop or Laboratory at Home

The average score of 177 pupils having a workshop or laboratory at home was 32.03; of 893 pupils not having a workshop or laboratory at home, 27.66. The cause and effect relationship referred to in Factor VI applies equally to this factor. It is interesting that of 26 pupils who had both a workshop and a laboratory at home, the average score was 39.46.

Factor VIII: High School Subject Preferred

The average score of 314 pupils who preferred a science subject to a non-science subject, was 31.81; of 756 pupils who preferred a non-science subject to a science subject, the average score was 27.29. Irrespective of other interpretation or influence, the data show that where a pupil's heart is, there is his mark also.

Factor IX: Expected Occupation

Of 436 pupils preparing for a scientific occupation, the average score was 29.57; of 624 pupils preparing for a non-scientific occupation, the average score was 27.56. It is surprising that a difference of only two points exists between those pupils who regard science vocationally and those who do not.

Factor X: Regular Work Outside of School

The average score of 241 pupils who had regular work outside of school was 30.18; of 829 pupils who had no regular work outside of school, the average score was 27.86. These data are interesting. Do the outside experiences of the working pupils provide them with a better knowledge of common science; or do the more ambitious or intelligent pupils secure outside work?

Factor XI: Education of Parents

Table III

Common Science Score in Relation to Education of Parents

Both College Grad.	*One Col. G. One H.S. G.*	*One Col. G. One Grade School G.*	*One Col. G. One Dead or No Education*	*Both H. S. G.*	*One H.S. One Grade School*	*Both Grade School*	*One Grade One No Education*	*Both No Education*	*One H.S. One No Education*
34.70	31.09	31.75	33	31.22	29.69	28.04	25.06	25.32	28.22

An examination of Table III will reveal that there exists a definite positive relationship between the score on the test and the education of parents. Pupils with one or more parents a college graduate, secured the highest score. There is a 5.6 per cent difference between this group and the group with one parent a high school graduate. The difference in score between the latter group and the group with one parent a grade school graduate, is 19.1 per cent.

Factor XII: Occupation of Father

The average score of pupils classified according to the father's occupation was as follows: professional, 32.47; business, 30.37; mechanic, 29.58; laborer, 24.96. It will be observed that there is a considerable difference in the average score between the children of the professional group and the children of the laboring group. The average score of those whose parents were dead was 26.01.

Factor XIII: Father's Nationality

Table IV
Racial Group Scores

Racial Group	*No. of Scores*	*Average Score*
American	294	31.26
British	228	28.76
Teutonic	133	28.37
Mediterranean	255	26.00
Semitic	74	27.85
Slavic	84	24.52

The average score of pupils of British, Teutonic, and Semitic parentage are close together. The average for the American group is considerably higher. The average scores of the Mediterranean and Slavic groups are noticeably less than those of the other groups. The data reveal a considerable difference in achievement between members of the earlier and later migrations.

Factor XIV: Size of Family

The average score for one-child families was 30.34; families of two or three children, 30.62; four or more children, 27.05. The bulk of studies on individual differences indicate a negative relationship between the amount of native intelligence and the number of children in family. In terms of this study, the wider social and coöperative contacts of the lar-

ger family do not give children more knowledge of common science as measured by the test employed in this study.

Summary

1. A pupil's knowledge of common science consistently increases with the amount of science passed.
2. There is a definite positive relationship between knowledge of common science and age.
3. Boys rank much higher than girls in knowledge of common science.
4. Pupils in the scientific curriculum are considerably superior to those in non-science curriculums.
5. There is a definite positive relationship between general school marks and knowledge of common science.
6. Science club members excel non-members; likewise, those with a workshop or laboratory in the home, excel those who are without one.
7. Pupils who prefer science as a subject excel those who do not; likewise, those who expect to pursue an occupation in the field of science as compared with those who do not.
8. Pupils who work regularly outside of school excel those who do not.
9. Knowledge of common science is positively related to the amount of education possessed by parents.
10. Pupils of Mediterranean and Slavic racial groups rank below those of British, Teutonic, and American origin.
11. Children of smaller families excel those of larger families in common science knowledge.

Museum Work in Biology

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Science teachers in cities having museum facilities should consider themselves quite fortunate and should avail themselves of the splendid opportunity to use them as aids in the teaching of their respective subjects.

Museum work as a part of the year's work in biology is required in my classes. Early in my teaching experience, classes were taken to the museum where the teacher pointed out things of interest and value. After two years of this type of museum work it was decided to abandon the practice for the following reasons:

(1) Large groups were difficult to handle. Transportation to the museum and back to school in a group was quite a problem. After reaching the museum the students did too much socializing to get very much out of such a trip. The feeling of freedom from school makes them flighty and less serious-minded. In pointing out things to the group there was difficulty in getting them all to see the object at the same time and consequently much repetition was necessary. On two occasions students became ill due to the excitement of crowding to be near the instructor when explanations were being given, and the values of the entire trips were lost.

(2) It seems unfair to take students from teachers' classes which they attend only five periods a week, when they have seven periods a week in biology. I feel that students in biology should be held accountable for outside work at the museum, greenhouse, zoo, or other place from which they might gain biological information just as they are held accountable for work at the library by teachers of English and history. It often happened that on days when trips were planned, teachers in other subjects had scheduled examinations and consequently were reluctant about granting excuses for a trip.

(3) Many students could not make the trips on Saturdays because of regular week end jobs or chores to be done at home, or for some other reason.

Because of the difficulties mentioned above, the following plan for doing museum work is now employed:

A visit to the museum is made by the instructor who jots down directions and questions on little cards. The directions include how to get to the museum, the hours it is open, which entrance to take, the floors and

room numbers where the observations are to be made, and the form in which to make the report. The directions, given just before the last six weeks of the semester, include questions that refer to representatives of each phylum studied in the course. Most of the questions can be answered by carefully observing the specimen or by reading the cards in the cases. A few, however, are thought questions. By way of illustration, the following example is cited.

In one of the rooms is to be found a huge case containing several rhinoceri in their natural habitat. Several little birds are seen on the animals' backs. The students are asked to find the case containing the rhinoceri and to explain the example of symbiosis shown in the scene. Other examples of directions and questions are "Find the case containing the cobra. Where is this animal commonly found? What is the significance of the dance of the cobra? Find the case containing eggs. What is the name of the bird that produced the largest egg known? Where would you expect to find fresh eggs of this type today?" The latter question is what I consider to be the thought type. The cards in the case label all eggs and explain that the bird that produced the largest egg is now extinct. If the student doesn't know what the word extinct means he must look it up before he can answer the question correctly.

Further directions are "Find the case containing the crocodile and the alligator. What are the differences between these two animals? Observe the sea bat. What is its scientific name? If you saw the recent movie entitled *The Sea Bat,* explain whether or not you think the title was appropriate. Observe the shrew. Why do you think Shakespeare named his play *The Taming of the Shrew?*"

These are just a few of the questions asked. Each student is required to purchase a pocket-sized note-book into which these directions are written. Two periods are used in giving directions carefully. The directions are written on alternate pages leaving the pages in between for answers and notes to be taken at the museum. These little books with the directions and rough notes are handed in with the report which will be discussed later. Students are given about four weeks in which to do the prescribed work. They are advised not to try to complete the work in one trip but to take two or three trips if possible. They are also advised not to go in groups of more than two or three.

After the visits to the museum have been completed, the student is now ready for the next step in preparing his report. He must obtain a large sheet of paper or cardboard and divide it into ten columns, each column for a phylum studied. Then he writes in the proper columns the animals seen at the museum. It was interesting to note that most of the

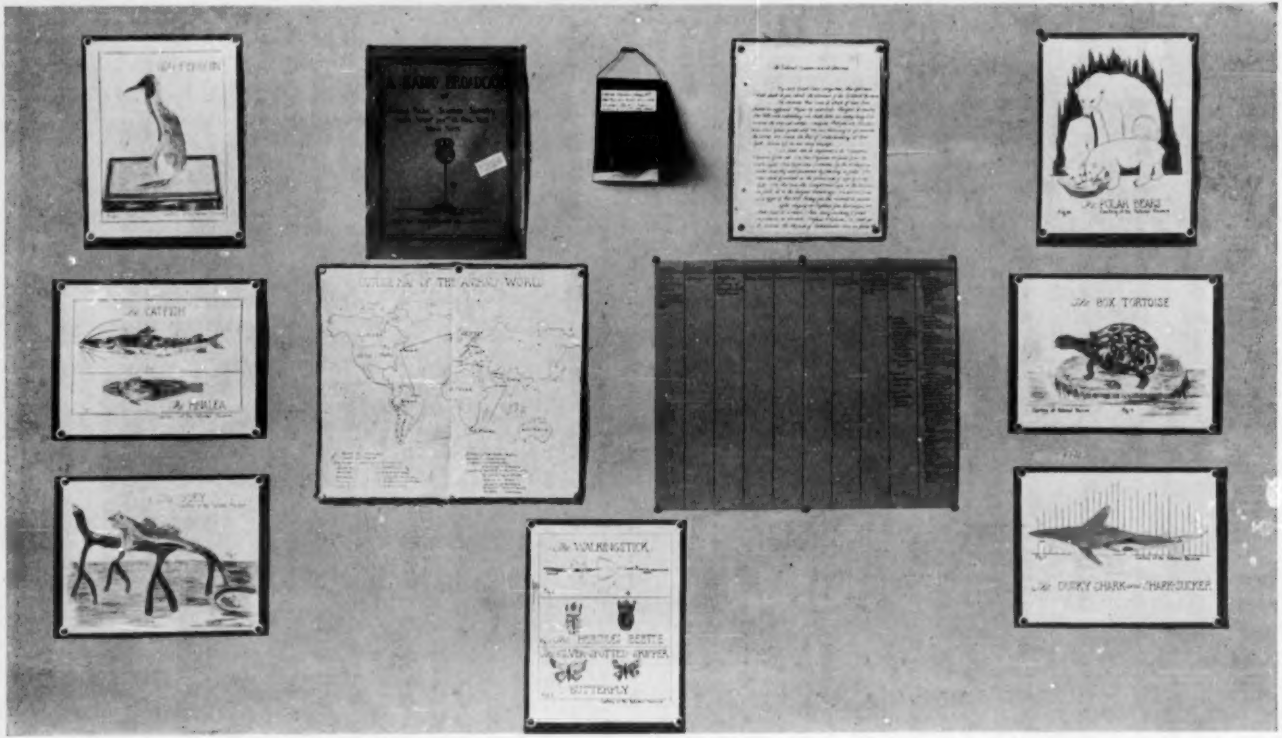

Plate 1.—Exhibit used by student.

students placed the eggs of various animals under the phylum protozoa, the blastula of lancelet under the phylum porifera, the gastrula, under the phylum coelenterata, etc. In this classification the student is held accountable for the classes of the phylum arthropoda, the orders of the class insecta, and the classes of the phylum vertebrata. When this classification chart is completed the student is ready to begin his write-up. The animals are to be introduced into the write-up in their phylogenetic order by referring to the classification chart. The answers to the questions asked about each animal must be included in the write-up at the point where the animal is introduced. When the essay is completed it must be handed in along with the booklet of directions and the classification chart. The students are urged to be as original as possible in writing up their trips. A variety of interesting forms have been received. Some were in the form of a letter, a dream, a scientific report, a dialogue, a radio broadcast of a trip around the world, and other unique types.

Plate 1 shows the work of a student who made her report in the form of a radio broadcast. It shows the cover of the booklet containing her broadcast, a copy of which she is sending to a radio fan who wrote for it. The booklet (upper center) contains the directions and answers to questions. On the map of the world (left center) is outlined the trip around the world on which these various animals were seen. At the right center may be seen the classification chart. The drawings represent animals seen on the trip. These drawings were not required, but they show what an industrious student may do.

At any time after the date on which all reports must be in, the students are held responsible for the answers to questions asked concerning the trip, during any class recitation or examination. Many questions and discussions regarding things observed often arise in class. The class abounds with interest as there is something which the students can talk about in common. Sometimes a search had to be made for the specimens listed in the directions, and in making the search many other things of interest attracted the students' attention. The instructor is flooded with questions concerning things which they were not asked to observe. Some students make additional trips to observe more carefully these things.

In conclusion, the major benefits to the students of doing museum work, according to the plan described, appear to be:

1. The obtaining of biological information as a part of everyone's general education.
2. Training in taking and carrying out directions.
3. Training in the wise use of leisure time.
4. Training in organizing and systematizing.
5. Correlation of biology with English, geography, and everyday life.

An Analysis of Some Professionalized Subject-Matter Courses in Science in Teacher-Training Institutions

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This analysis was conducted as a part of an investigation of a Committee on Teacher Training appointed by the National Association for Research in Science Teaching. It logically follows two earlier investigations, the first a questionnaire to instructors in science in teacher training institutions, which had as its purpose the collection of opinions of what constitutes professionalized subject-matter;[1] and the second an analysis of professionalized courses by means of specially prepared blanks filled out by students after visiting certain professionalized subject-matter classes in teacher training institutions.[2] Whereas the first two reports summarized (1) opinion as to what professionalized courses are, and (2) accounts of what actually happened in certain professionalized courses, the present report summarizes descriptive accounts of their own professionalized courses by 19 instructors. The purpose has been to discover what specific things these instructors had done toward professionalizing these courses.

It is to be noted that these courses are statedly subject-matter courses. They combine the teaching of subject-matter and the study of organizing and presenting subject-matter to classes which will later be taught by the students in training. There is a clear assumption that so-called methods courses shall include subject-matter. There is likewise a clear assumption that subject-matter courses for prospective teachers will be devised specifically for these teachers—that they will not be conventional subject-matter courses intended alike for engineers, dentists, doctors, and farmers, as well as for teachers. It seems to follow that selected subject-matter for elementary, junior high, and senior high school teachers should not be identical, but should be specifically organized to meet the needs of the particular student-teacher group.

The questionnaire including 31 items was sent to a relatively small number of instructors who, in an earlier questionnaire,[3] listed professionalized subject-matter courses in their institutions. The supposition was that those who were teaching such courses would be most likely to supply valuable information on the subject of professionalization. This report is based upon nineteen replies received.

An outstanding conclusion from this and the earlier investigations is that relatively little has been accomplished toward professionalizing subject-matter courses in science. Almost all of the professionalization has been done in teachers' colleges and normal schools. It has been most successful in the latter because they prepare elementary-school teachers. Elementary science is a relatively new venture. It is obviously easier to formulate professionalized courses in situations where there are no other existing courses tending to prevent the introduction of new and ideally planned professionalized courses. The difficulty in colleges and universities is largely one of existing courses in the various conventional sciences, and the error of assuming that a course in general biology, or in general chemistry, or in general physics is a certain definite and invariable thing. An introductory course in biology for future biologists, for example, is not suited to the needs of all students whatever their future vocations! From an administrative standpoint, especially in small institutions, it is obviously much easier and more economical to have one general biology course for all students. It requires experience in teaching to fully realize that various sciences, if taught as such, must be adapted to the particular group if these sciences are to successfully function in the lives of the group members. Perhaps some of our problems would be solved if conventional subject-matter course designations were replaced by others. Instead of needing then, for example, a training course in physics for teachers of secondary school physics, which, by the way, has not even yet been widely attained, a better designation might be, science for prospective teachers of 11th grade pupils; or more specific still, problems of the physical environment for prospective teachers of 11th grade pupils. It is evident that professionalized course problems are far-reaching, but that they will be in the way of solution when the kind of courses which pupils in our elementary and high schools need are better settled than they are at present. Certainly, it is appropriate to conclude that more definite, specific, and purposeful training of teachers for particular jobs is greatly desirable. This can undoubtedly be accomplished partially without changing present course designations, if the pupil-minded rather than the subject-matter-minded viewpoint is maintained.

There is noticeable in the questionnaires returned a reluctance of the instructors to pose as authorities on professionalization of subject-matter; also, in some cases, not always a clear notion of what the professionalization of subject-matter implies. There is also manifest a noticeable difference in ideas dependent upon the former training of the instructor. For example, it is almost possible to pick out from the replies, those

who have come under the influence of certain schools which have emphasized certain concepts bearing upon professionalization; or those who have been engaged for a long time in teaching the conventional sciences with a minimum regard for the specific and differentiated needs of students in their classes. Indeed, an outstanding conclusion of the need for specific and exclusive institutions for the training of teachers is almost forced upon one. This implies that it is now high time that all teachers be specifically and professionally trained in institutions which are not trying to train other professional groups in the same classes. The teachers' college should have as its sole function the study of public educational problems, the settling of the theoretical and practical problems of public education, and the training of teachers for all public schools. This is merely a reasonable arrangement which is paralleled by our schools of medicine, dentistry, engineering, law, and the like.

Replies to the questionnaire items have been tabulated. Judged by a significant majority of the expressions of opinion by the instructors of the nineteen professionalized courses represented, the following are indicated as useful considerations in planning professionalized subject-matter courses:

1. Emphasis upon consumer or functional science.
2. Teaching procedures which may be adapted to lower school situations.
3. Content which may be adapted to lower school situations.
4. Illustrative directed and supervised study.
5. Practice in freedom in informal discussion.
6. Outlines and textbooks for guiding study.
7. Long time assignments with frequent sub-assignments.
8. Emphasis upon the practical, the cultural, applications, social and economic aspects, and the historical background.
9. Some emphasis upon specific skills, attitudes, and habits.
10. Selection, organization, and presentation of subject-matter for the specific situation.
11. Specialized individual student activities apart from group activities.
12. Instructional units adapted for the particular group.

It is hoped that the items may stimulate further attention to professionalization. It is certain that teachers are not yet being properly prepared for teaching science. Even though more careful selection of prospective teachers be made, we cannot hope that a science curriculum composed largely of conventional courses designed for no one in particular

unless it may be the prospective biologist, physicist, or chemist, will meet the needs of prospective teachers of elementary, junior high, or senior high school pupils. Teaching is a profession which demands more specific professional training. The slogan that we are teaching pupils, not subjects, has not yet sunk in sufficiently. It has been displayed enough for several years past but hasn't yet taken a grasp on many minds, because of the inertia of past tradition and convention. This is another of the many indications that the whole matter of educational aims and objectives is still the most vital educational problem. Should the school help to develop personality and character, and help solve the problems of happy vocational, avocational, and social life? Everyone will say, "Yes," but if it is to be done, it must be done through a more direct attack on those problems. The most important outcomes are not chance concomitants of instruction which never gives attention to them. The surest way to accomplish an objective is to have it clearly in mind and plan directly for its accomplishment. Stated appositely by Sisson[4] " . . . learning to do one thing is on the whole more likely to hinder than to help in doing something else." Interpreted and turned around—if a teacher is to assist a pupil in the development of his personality and character, he will not do it through teaching a conventional course which takes no thought of such development. A professionalized course should seek to train teachers to perform the kind of teaching tasks which they will be expected to do later. Conventional subject-matter courses not designed for any particular group are poor devices for training teachers.

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What Principles May Be Used for Guidance in Planning a State Program for Teaching Science

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In suggesting principles that may be used for guidance in planning a state program of science teaching, I shall present several theses. First, I should like to describe those which are to me fundamental and then those which are of less importance from a philosophical point of view, but important, nevertheless, for the success of a program of science teaching.

(1) *Civilizations are built largely on the advances made in science.* This is indeed an age of science. Modern life is founded largely on discoveries in science that have been made during the past thirty years. It is scarcely necessary to call your attention to modern means of transportation and communication, to technological developments, to the advances in medicine and the control of disease, all of which make our present-day world, its crowded cities and generally enriched living possible. As the discoveries in science that have already been made, as well as those that will be made in the future, make their contribution to man's control of his environment, a new social order will emerge with new systems of thought.

(2) *It is necessary for the members of our society to understand important scientific principles and methods in order to appreciate modern life and make satisfactory mental adjustments to it.* It is somewhat humiliating to educators, particularly science teachers, to realize the extent to which so many of our people are governed in their thoughts and actions by superstitions. These superstitions exist in ignorance and they are usually associated with natural phenomena. A program of science education should provide the understandings necessary to release man from the bondage of these superstitions.

(3) *An understanding of scientific principles is essential for the intelligent use of their practical application to every-day life.* One of the most important aims for science teaching is the diffusion of health knowledge in order that society may be governed by a general understanding of such knowledge and not by authoritative regulation. For optimum use of automobiles, radios, inventions and other materials of every-day life, as found in this world of science, every normally intelligent person should have a general understanding of the scientific principles involved.

(4) *The general diffusion of knowledge of important scientific facts and principles and the habitual use of scientific methods is necessary equipment for racial progress.* Unless the enormous store of knowledge that is now held by the few at the top in the scientific world can be diffused generally and become the property of the many, the many cannot be expected to follow wisely the leadership of the few. Furthermore, this diffusion process should be carried on vigorously, not to close the gap, that is impossible, but to prevent a dangerous chasm. It is the business of those interested in the teaching of science to bridge this gap and to serve as one important medium for the diffusion of scientific knowledge.

Each of the four statements listed above might be elaborated upon at some length with justification. To me they are fundamental. For more direct application to a state program in science, I should like to list the following.

(5) *A state program of science should guide teachers to direct pupil learning in the directions indicated in the preceding theses.* In my opinion, education in science is as fundamental as training in the use of our English language. Instead of being a step-child in our elective system, science work should become a "constant" throughout elementary- and secondary-school grades. The science courses of study and the syllabuses should be planned for all elementary and secondary pupils, not merely for those who are going into college and not merely for those who are going into vocations closely related to the study of the sciences. I cannot see the justification for science courses with vocational slants in our public school system. Regardless of the vocations our secondary-school pupils may wish to enter, they must all live in this world of science. They must practice, in general, the same health habits. They will use the same means of transportation and communication. They will use the same products of modern invention and certainly they should use, as far as it is humanly possible for them to do so, some of the scientific habits and methods in their thinking and acting.

In the Thirty-first Yearbook of the National Society for the Study of Education, a program for the organization of science teaching in our public schools has been ably set forth. While some of us may disagree with the emphasis given in this yearbook to this or that point of view, we cannot escape the conviction, it seems to me, that fundamentally the proposals are sound. The yearbook proposals were never intended as a prescription formula to be filled out by the curriculum pharmacist. The general principles proposed were intended for guidance and it is from this point of view, reported in this spirit, that the yearbook has made its contribution to science teaching.

With state syllabuses organized around principles and associated scientific methods, the adaptation of each to local conditions should be greatly facilitated. The prescription of the state syllabuses in the past of certain items for study, such as the grasshopper or the crayfish, will not appear in future syllabuses. Instead, classroom teachers may select the crayfish, if desirable, for teaching certain biologic facts and principles. The city teacher may use one specimen; the rural school teacher, another. The end to be arrived at is the same. Personally, I no longer can see justification for separate city and rural school syllabuses. Pupils on the farms are living in an age of science almost to the same extent as pupils in an apartment house in a large city. They experience practically the same weather conditions, eat the same foods, and, in general, use the same inventions. The state syllabuses in elementary-school science and in general biology have been planned principally with these facts in mind. The general biology syllabus, for example, is equally well adapted to city and to rural school purposes. It was planned not for the few who might elect biology as a special subject of special interest, but for all tenth-grade pupils in the hope that the majority of them, if not all of them, would have the privilege of taking the course. The same principles apply to the other state syllabuses in science, including the advanced physical sciences.

(6) *The social implications of scientific principles and methods should be emphasized in science teaching.* The accusation that teachers of science have restricted themselves too closely to formal technical development of subject matter topics in their fields may be justified to a large degree. In my opinion, a teacher of physics should point out the social implications of new discoveries and theories in his field. Even in connection with such a device as the electric-eye, the possibilities for putting men out of work should be indicated. In chemistry, in connection with teaching the nitrogen compounds and their instability, the teacher should point out the uses to which explosives may be put for the benefit of mankind in building dams, in excavating, in forestry, and in other ways. The pupil should not be allowed to look upon explosives merely as instruments of warfare. In biology, the implications of the laws of heredity may be pointed out with reference to the human race. The new State syllabus in general biology was purposely constructed with this social emphasis in mind.

(7) *The science program should be administratively feasible.* Among the many administrative problems that might be considered in connection with this thesis may be listed the following: teacher-training, equipment, and teaching schedules.

It would be futile to attempt to put into practice a state syllabus in science for which there were no trained teachers. Indeed, it is only within recent years that teacher-training institutions have made serious effort to furnish well-trained teachers for general science work. Such teachers are even now relatively scarce. Under these circumstances it would be foolish for example, to plan a state syllabus for a tenth-year course in general science, even if such a course were desirable.

Science equipment should, of course, be adequate to carry out acceptable purposes of science work. Tradition has played a very large part in the past in the selection of science furniture and apparatus. We can no longer justify the maintenance of separate lecture and laboratory rooms which are in use only a small part of the school day. Science teachers generally must be alive to this issue if we believe the demonstration and individual laboratory work to be important. There has been a general movement on the part of science teachers to deformalize their laboratory work. Laboratory periods are no longer conducted on Tuesday and Thursday afternoons during the seventh and eighth periods, but laboratory periods are now being scheduled when administrative conditions permit, at a time when laboratory work is necessary or appropriate. This movement has led towards the establishment of combination recitation laboratory and demonstration rooms, with the teacher demonstration desk in the front of the room, tablet armchairs immediately in front of the demonstration desk, and individual laboratory tables in the rear of the room. This science laboratory is flexible and may be used in small schools, if necessary, for recitations in mathematics or other subjects when not in use for science.

With the advent of combination recitation and laboratory rooms has come also the hour period of instruction. The tradition of requiring two periods of laboratory or "hand work" for one period of so-called academic work, can no longer be justified. For many years teachers in other fields have looked somewhat with contempt upon laboratory work of pupils in science. At the present time, however, we hear of commercial laboratories, social-studies laboratories, English laboratories, and of the library as a laboratory for all school subjects. While the teaching of these other subjects has been gradually approaching the laboratory method, teachers of science on the other hand have drifted in the opposite direction toward formal recitation and lecture work. While I do not wish to enter into a controversy as to the relative merits of the demonstration versus the individual type of laboratory work, I should like to call attention to the fact that this problem has never been exhaustively treated in any of the investigations that have been made. There is evidence to show

that both methods have their merits and both probably deserve a large place in our science teaching. With the administrative pressure that was brought to bear during and after the World War, the demonstration method gained considerable headway. It is now generally accepted that although pupil activity should be encouraged as much as possible throughout the elementary- and junior-high-school grades, the experimental work in science should be carried on largely by teacher demonstration. Beginning with the more specialized science courses, in the tenth grade, however, it is my opinion that laboratory work should be required of every individual pupil.

The teaching schedules in the majority of New York State schools call for six periods a week, two of which are laboratory periods. A few schools require seven periods. In the mid-west and south-west, as well as in many other parts of this country, seven periods a week is a general requirement with four periods devoted to individual laboratory work. In New York City, however, the general schedule is five periods a week for all the laboratory sciences, and in my opinion, this schedule of five periods a week should operate for all schools. A period devoted to individual laboratory work is as valuable if not more valuable than the equivalent time spent in English, Latin, or any other subject. Since the six- and seven-period schedule plays havoc with the organization of high-school schedules and actually tends to limit opportunities for pupils to study science, the policy of requiring extra laboratory periods should be abandoned and future state syllabuses should be planned with the five-period schedule in mind. Our most recent syllabus in general biology is planned for such a five-period schedule. In the revision of the other state syllabuses, this policy will probably be followed.

(8) *State syllabuses should be subject to continuous revision.* As new discoveries in science are made, their relation to important generalizations, as outlined in syllabuses, should be determined. Discarded theories should be relegated to historical treatment and the new materials should be included in the syllabus. The organization of syllabus materials in terms of principles, rather than as a mass of information, should discourage the cramming in of isolated bits of information here and there as represented in some of our textbook developments.

As our knowledge of the psychology of learning warrants, changes should be made in our state syllabuses. If careful investigations in the teaching of science reveal, for example, that certain facts are too difficult for average pupil learning in a certain school grade, a revision of syllabus materials is indicated. There is so much work to be done along these lines that teachers of science who are interested in research should look forward to many years of fruitful work.

As new social implications of scientific knowledge arise, state syllabuses should be revised. Science teachers need to bend their scientific "backs" and make science teaching more human that it has been in the past. Science should be taught for constructive purposes in building new systems of thought that will supersede the old and lead definitely in the direction of a better existence for the individual and the race.

Science Enrollments in New York State High Schools

Total enrollment of Sec. Schools		General Science			Elementary Biology		
		Schools teaching General Science	*Pupils enrolled in General Science*	*Percentage of total enrollment*	*Schools teaching Elem. Biology*	*Pupils enrolled in Elem. Biology*	*Percentage of total enrollment*
1926–27	353,739	118	31,008	9.04	840	76,289	21.56
1927–28	381,534	143	24,731	6.48	838	80,318	21.05
1928–29	412,213	193	30,276	7.34	810	85,730	20.79
1929–30	434,079	232	36,513	8.41	790	92,736	21.38
1930–31	471,057	380	45,151	9.58	751	97,276	20.65
1931–32	500,664	426	57,983	11.58	696	107,973	21.56

Total enrollment of Sec. Schools		Advanced Biology			Physical Geography		
		Schools teaching Adv. Bio.	*Pupils enrolled in Advanced Biology*	*Percentage of total enrollment*	*Schools teaching Phys. Geog.*	*Pupils enrolled in Phys. Geog.*	*Percentage of total enrollment*
1926–27	353,739	38	10,496	2.96	134	5,857	1.65
1927–28	381,534	42	13,713	3.59	192	7,569	1.98
1928–29	412,213	52	15,514	3.76	201	8,560	2.07
1929–30	434,079	54	18,807	4.33	215	9,180	2.11
1930–31	471,057	58	19,858	4.21	226	10,491	2.22
1931–32	500,664	63	23,950	4.78	225	12,613	2.51

Total enrollment of Sec. Schools		Physics			Chemistry		
		Schools teaching Physics	*Pupils enrolled in Physics*	*Percentage of total enrollment*	*Schools teaching Chemistry*	*Pupils enrolled in Chemistry*	*Percentage of total enrollment*
1926–27	353,739	657	24,321	6.84	408	24,668	6.97
1927–28	381,534	674	26,673	6.99	422	24,266	6.36
1928–29	412,213	658	26,292	6.37	457	28,192	6.83
1929–30	434,079	670	29,656	6.83	455	30,127	6.36
1930–31	471,057	677	30,183	6.54	490	31,896	6.77
1931–32	500,664	712	35,502	7.09	526	37,797	7.54

How Chinese Chemists Name the Elements

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化學元素之中文名稱

THE CHEMICAL ELEMENTS IN CHINESE

馬夌雲 懷普
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名不正則言不順

"If the name is not correct, then the talking is not convenient."

There is an old Chinese proverb which reads, "If the name is not correct, then the talking is not convenient." It expresses the importance of a practical, adequate nomenclature in any branch of learning. More freely translated, the proverb states in effect, "Until names and ideas are made clear, discussion (and teaching) will not be effective."

Imagine the difficulties, then, of the pioneer students of chemistry in China, who about a half century ago were struggling with the task of translating the technical terms of Europe and America into Chinese, using characters as dissimilar in form and principle from the Roman alphabet as the nations themselves are removed in longitude. It is the purpose of this article to tell but one small part of the story, merely to illustrate the nature of the steps that were necessary to throw off the burdens which a cumbersome terminology placed upon early chemical science in China. It is possible that a lesson may be learned from this recital. Are not the scientific terms taught in the classrooms of the United States too frequently "nothing but Chinese" to the laboring students?

Our presentation will concern only the naming of the chemical elements in Chinese. A group of Chinese textbooks, some thirty in number, ranging in age from twenty-five years to but a few months, together with a group of catalogs and price lists issued by Chinese firms, have furnished the necessary information.

Early Methods of Naming the Elements

Chemistry in China, as in other nations, was a practical art before it became a science. Although not recognized as elements, a small group of these simple substances had long been in use and had received common names. The king of metals was *ging* (gold), the most useful *t'ung*

(copper); a strange stone that burned was *liu* (sulfur). The people had already classified most substances, irrespective of their chemical state, into four groups—metals, stones, gases, and waters—and the Chinese character used was usually a compound in which one portion represented the class.

It was but natural that the early Chinese workers and teachers of chemistry retained the long-used names for as many substances as possible when they presented in writings and lectures the conception of elements as forms of matter. A number of these names are shown in Table I, Part A. This was the first policy of translation, and was satisfactory as far as it went. It did not take care, however, of the elements—some fifty or sixty in number—for which no common names existed.

Table I. Early Names of the Elements

A. Names of Antiquity

charcoal	碳	lead	鉛	sulfur	硫
gold	金	mercury	銾	tin	錫
iron	鉄	silver	銀	zinc	鋅

B. Descriptive Names

bromine	溴水	"stench water"	mercury	水銀	"water silver"
calcium	石精	"stone spirit"	oxygen	養氣	"nutritive gas"
chlorine	綠氣	"green gas"	platinum	白金	"white gold"
hydrogen	輕氣	"light gas"	silicon	沙精	"sand spirit"

The second plan in translating the names of chemical elements into Chinese was to select roughly descriptive terms, indicating the properties of the elements as they were described in the English and European texts. The student learned of chlorine as "green gas," mercury as "water silver," and the like. The method was fairly satisfactory for approximately a score of the elements readily studied in their free state in the laboratory. Certain of these names are shown in Table I, Part B.

The remaining majority of the elements for which neither ancient usage nor convenient observation had provided names were designated

by a third scheme—the last resort of a translator—an imitation of the sounds of English or Latin names. Usually one or two Chinese characters were required to present each syllable. The sequence of sounds formed a first-class group of "nonsense syllables" to the Chinese ear, and without doubt prompted many classroom remarks on "the absurd names invented by the foreign chemists." Several elements named by this cumbersome method are shown in Table II, Part A.

Faults of the Early Names

Three serious disadvantages of the Chinese terminology as applied to chemical elements were apparent from the very first—(a) lack of simplicity; (b) lack of uniformity; (c) lack of stability.

Simplicity is a most valuable characteristic of any freely-used scientific nomenclature. When from three to five Chinese characters were necessary to name one element, serious difficulties attended the naming of a complicated compound. The English and the European languages have the same unsolved problem in their chemical terminology, using four syllables to name each of many elements where one syllable would suffice, and extending to ludicrous lengths the "jaw-breaking" names of compounds.

The lack of simplicity is evident in the Chinese names given in Table II, Part A.

Uniformity is a necessity in scientific terminology. The nature of the Chinese written language invites widely varying usage. There are many homonyms in the Chinese speech—words pronounced the same, but having different meanings. (Analogies in English are *air* and *heir*, *one* and *won*, *doe* and *dough*, etc.) Chinese characters present meanings, just as do the spellings of words in alphabetical chirographies. For any imitated sound of a syllable in the name of an element there might be several Chinese characters, and these were used to a confusing extent by the different translators.

Table II. The Imitation of Sounds

A. Syllable by Syllable

aluminum	哀盧彌尼恩 ai lu mi ni en	natrium	內脫利武母 nei to li wu moo
fluorine	夫羅而林 foo le erh lin	wolfram	阿爾佛蘭謨 a erh foo lan mo

B. The Confusion of Dialects

aluminum	cobalt	potassium
亞爾蜜紐謨 ya erh mi new mo	箇拔爾篤 ko ba erh tu	剝篤斯 po tu ssu
阿呂迷武母 a lu mi woo moo	古抱爾脫 ku bao erh t'a	博笪休摩 po ta hsiu mo
阿盧蜜拉 a lu mi la	箇拔爾 ko ba erh	卜對斯恩 p'u tui ssu en
亞美爾 ya mei erh	苦抱爾 k'u bao erh	潑台西恩 po ta hsi en
哀盧彌尼恩 a lu mi ni en	鈷暴爾脫 ku bao erh t'a	八大司 poo ta sa
阿鋁蜜尼恩 a lu mi ni en		婆大仙 pa ta ssu

Adding to the embarrassment were the various pronunciations of characters in the many different dialects of China. As a teacher or author imitated the sounds of English names of elements, it is natural that the symbols he selected would present the sounds according to the prevailing dialect of the region. The results of independent translations by widely separated workers is shown in Table II, Part B, in which various names published in Chinese texts for a single element are given.

Stability of scientific terms over considerable periods of time normally suffers from changing concepts. These modifications are characteristically slow in established nomenclatures. The Chinese names for the elements not only varied from place to place and dialect to dialect, but they changed rapidly from period to period. A Chinese student might learn the characters for a certain element one year, and find next year that his teacher preferred a different set of characters, based on newer publications, or a fancied improvement in the imitation of the sounds of the English name.

Revised Terms for the Elements

The need for a revised, simple, uniform chemical nomenclature in China had been felt by teachers of chemistry and industrial workers in that field long before any official action was taken in the matter. Revision

was started independently by various groups of individuals who had contacts with each other. Particularly, the policy of using only one Chinese character for each element began. Many revised terms became stabilized by usage and publication. In the year 1915 the Chinese Ministry of Education appointed a Committee on Scientific Terms, which after several years of labor presented a comprehensive list of inorganic chemical terms—including a Table of the Elements—which was officially adopted.

In this new list, three principles are applied to the naming of the elements: (1) Only one character is allowed to each element; each, however, is compound; (2) The ancient classifications—metals, gases, stones, waters—are retained as one of the combining characters; (3) The other combining character describes some simple property, or if that is beyond the powers of one character, imitates one syllable of the English or Latin name.

Table III. The New Names

A. The Four Classifications

金 metal (gold)	气 gas	石 stone	氵 water

B The Two-in-One Characters

antimony	銻 metal:"ti"	fluorine	氟 gas "fu"	iodine	碘 stone:"dine"
natrium	鈉 metal:"na"	hydrogen	氢 gas light	selenium	硒 stone:"hsi"
platinum	鉑 metal:white	chlorine	氯 gas green	bromine	溴 water:stench

C As the Layman Reads

antimony 銻 "metal of the younger brother"; boron 硼 "stone of friendliness"; europium 金憂 "metal of sorrow"; iodine 碘 "stone of the law"; osmium 銤 "golden rice"; radon 氡 "gas of the east"; selenium 硒 "stone of the west"; tellurium 碲 "stone of the emperor"; xenon 气重 "gas of heaviness."

In the Official Table of Chemical Elements there are 69 of the metal group, 11 of the gas group, 9 of the stone group, and 1 of the water group. The sum of these is 90; Chinese names for the elements most recently discovered, Virginium and Alabamine, have not been adopted officially. Table III, Part B, presents a few names of elements from the revised list, indicating the compound parts of the single characters.

As the Layman Reads

Scientific terminology is always mysterious to the layman. Reading (or hearing) a word for the first time conveys only a series of sounds that are "translated" by the ear in terms of any words that are already familiar; if the syllables are indeed strange the term is then wholly meaningless.

The Chinese student who possesses skill as an interpreter is frequently asked by Americans, "What do these characters really mean?" When he replies, "They are the names of the elements," he is pressed further. His response is finally a literal translation of a character as it would appear to a Chinese layman on his first contact with the term. A group of these "translations" are given in Table III, Part C. Their total lack of relationship to any property of the element is apparent. Contrary to what American friends of the Chinese student would like to believe, there are no figurative connotations in these terms.

Analogous "translations" of the English names of elements will make this matter clear. If the Chinese student were equally insistent, his American instructor might be forced to "interpret" the "hidden meaning" of *iron* as "I run"; of *iodine* as "I shall eat"; of *antimony* as either "a state of poverty" or "a wealthy aunt." Such novelties of translation in either direction, therefore, have no etymological significance.

The Elements in Equations

The Chinese characters assigned to the elements are names, *not* symbols. To employ them in writing equations would be as inconvenient as the use of English words for the same purpose. All Chinese texts of chemistry print equations in the English form, using Roman letters, Arabic numerals, and the conventional mathematical symbols. Since the English language is widely taught in China, students of chemistry have no unusual difficulty in learning and understanding the nature of reactions set forth in this fashion.

The Evolution of the Elementary Science Program in the Cleveland Public Schools*

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It was just five years ago, in February, 1928, that the Elementary Science Curriculum Center was established at Doan School in Cleveland. This suggests the possibility of designating the development of the science curriculum as a Five-Year-Plan. The men who directed the Soviet experiment of the famous Five-Year-Plan of Russia outlined in detail the size and kind of each factor and just where it was to be built; where coal was to be mined and how; the size and location of the hydro-electric stations, the harnessing of the power from the Dnieper and other rivers, a definite program for every machine—so many products an hour, a day, and a year. These aims were based on the ten-year survey of all Russia—its resources and its needs. Now it is apparent that their Five-Year-Plan did not work as scheduled and that they are actively engaged in making more extensive charts, drawings, and specifications for a second Five-Year-Plan.

The development and inauguration of elementary science in Cleveland differs from Russia's Five-Year-Plan in that we had only a few definite plans, and at the beginning could not have believed that the work would attain its present proportions within so short a period. Of course, at the outset, we had certain definite ideas and ideals—certain goals that we hoped might some day be attained—but we had no idea as to when these would materialize.

Instead, there were a number of questions to which we were trying to find the best answers. We were endeavoring to construct a course of study based upon the fundamentals of the children's natural interests and the proper adjustment and proportional distribution of units that should be about animal life, plant life, and physical science. Utilizing children's interests does not mean following Johnny's whims today and Mary's tomorrow, for I do not believe such a procedure possible in educating 75,000 pupils in a large elementary-school system. But by studying the interests of many children we can elicit the special interests of each age group. Data on about 25,000 pupils have been collected in our studies in Cleveland.

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Our plans have evolved from concrete findings and the results of experimentation. We have tried not to project our plans much beyond the actual developments. We have wanted the growth of the science curriculum to be a natural unfolding, not a forced development.

Moreover, we have endeavored to maintain an open mind and a scientific approach to all problems. We have not used experimentation to prove preconceived notions and theories. Such a process would rest on an unsound basis, and the results acquired would soon be overthrown, so we have built upon the foundation of actual findings and observations.

At the time when the Science Curriculum Center in the Cleveland Elementary Schools was started, a little science was being taught by a teacher here and there who was interested in the subject. That was all. So at the beginning most of the teachers neither had training for, nor experience in, the teaching of elementary science. This was really fortunate, because we were building something new and there were no traditions to be shattered.

The use of one school as a laboratory for the purpose of evolving and planning a new course of study has proved most practical. This furnishes a means of developing a workable curriculum, as contrasted with a merely theoretical one planned by a committee which projects imaginary requirements as to what children of certain age and intelligence ought to study. Of course, experimental work with eighteen teachers presents a good many difficulties. But these were adjusted by making plans for the school as a whole, and also by working with the individual teachers. There are those in educational circles who seem to think that experimentation is merely trying something new or doing a thing in a different way and finally judging the success of the experiment by whether or not it pleased those who initiated the project. Someone has said most aptly, "Most school experiments are proved successful." There seems to be some trend in most of us that keeps us from saying or even allowing ourselves to believe that anything we have taught was in any way unsatisfactory. Hence, in the beginning of our experimental work, an effort was made to get all the teachers to look at the problem objectively. We knew that the reliability of findings could not be based on opinion alone, so we organized plans which required many data that were to be recorded daily. To give the teachers time for this work two extra teachers, or "free teachers," were provided for the building. By this plan each regular teacher was allowed a half-hour each day for these extra duties. The free teachers also assisted in the tabulation of data and in the preparation of material for the various units of study. As the work has progressed, the need for these extra teachers has been eliminated.

In this paper it would be impossible even to outline all of the work at the Science Curriculum Center. But some of the features accomplished through this school, as well as some of the problems which presented themselves in working out the curriculum, should be mentioned.

a. The experimental curriculum center developed some outstanding science teachers, for as much emphasis had to be placed on the method of teaching science as on the subject matter. In this way it served as a training school for science teachers. A number have been transferred from the center to teach science in other schools, and thus form a nucleus for the development of science teaching.

b. Other teachers in the system were stimulated to try some of the science units they saw the curriculum teachers using. Doan school was open to any Cleveland teacher every Wednesday and many teachers used this visiting privilege.

c. The work created a desire on the part of many teachers to become science teachers, and they soon realized the necessity of familiarizing themselves with scientific information and of pursuing courses in science.

There are many advantages in working out a science course, or any other course, for that matter, in a school with the children's experiences, interests, and reactions as the focal point. It is much superior to a plan in which members of a committee choose from the sciences the subject matter they think children ought to know and clamp this material down on the child in a more or less rigid fashion. And so the units are developed with the pupils in a number of classes. From these are chosen the most worthwhile material and experiences and these are recorded in such a way that others may learn the same thing. In planning our units in the science curriculum, we have stressed the method of learning, a phase that often is overlooked in planning a course of study. With us, the study of science does not consist in merely reading about science. It is the learning through experimentation, observation, and the problem or question is supplemented and verified by reading.

I might digress here a moment to present a story of one child's idea of scientific method. The child had just given a report on the grasshopper. When she had finished, the teacher said, "That was very good, but you didn't follow the outline. What did you follow?" And the child answered, "I followed the grasshopper."

As a result of the experiment in one school, there have followed numerous developments and accomplishments.

1. Elementary Science Readers' Guide

A problem that confronts every teacher of elementary science is the finding of books and articles that contain authentic information about the topics being studied. So one of the first things that we did was to prepare a mimeographed book of 105 pages called "An Elementary Science Readers' Guide." This is a brief annotated bibliography with page references, arranged by subjects, and aids both teachers and pupils in finding information quickly. References are listed from those books that are now to be found in many of our elementary schools. There are 222 titles of science books and twelve series or sets of science books on our approved supplementary book list. Our aim is to keep this a carefully selected functioning list, by retaining only those books that best serve our purpose, by adding the better books as they come to our attention and by eliminating those less satisfactory.

We are making a special effort not to use any of what I call "namby-pamby" material on science that has been written for the young child. Such books give practically no real information and are at times most misleading. These may have some merit from the standpoint of the imaginative story, but have little value in the teaching of science. Nature has created a much more interesting and fascinating true story than the mind of man can imagine in fanciful tales.

2. Equipment for Science Rooms in Elementary Buildings

In planning equipment for the science rooms, we first considered the needs. There must be opportunity for the attractive display of much objective material and the use of this by the pupils. In selecting the furniture that best satisfied these needs, we drew up plans and specifications and had the furniture made, if the available equipment did not serve our purposes. For example, the demonstration tables that are found in Science Equipment Catalogues are two inches too high, so we planned a simple one that serves as a teacher's desk and also may be utilized for demonstration purposes.

Above all, we did not want the elementary science rooms to be miniature high school or college laboratories. Unquestionably there is opportunity for the science rooms in the elementary school to be most attractive and most stimulating to boys and girls and I am happy to say that in many of our schools this is true today.

3. Supplies

If elementary science is to be taught properly, a large amount of material must be supplied, for this beginning of science must not be merely

a reading about factual material, but must be a study of this material in so far as possible.

We have worked out a minimum list of supplies which we consider fundamental to our course of study. This costs approximately $40.00 and consists largely of supplies necessary for the study of the physical sciences.

For the study of plant life, the Garden Department furnishes much of the material, such as fall flowers, bulbs, small potted evergreen trees, house plants, etc. Wherever possible, we study growing things where they grow. For example, within three blocks of every school building in Cleveland there is a variety of trees. It is easy to take the boys and girls to these trees. And so it is with many other phases of natural life.

We are at present working on a unit giving information about specific points of interest in each of the city parks and in the large Metropolitan Area lying outside the city proper with directions for reaching each of these. In Cleveland, we are indeed fortunate in having such a wealth of material at our door, such as the zoo, wildflower reservations, brooks, rivers and lakes, marked nature trails, etc. Many of these are within walking distance of schools in various sections of the city.

Children twelve years of age or younger may ride on the street cars, during school hours on school days, for a penny fare. For a nominal sum, classes may have a worth while study experience of more distant sections, if they know just where and how to go, and exactly what they are to study. Some schools hire a bus for these excursions or field trips.

In providing animals for study, there are several factors with which to cope. One is the element of mortality, for animals will die, although sometimes the opposite is likewise true and an animal may become too old to be enjoyed by the pupils. Taking care of these animals during the summer vacation is another problem. Of course, they may be farmed out to teachers or pupils. However, this introduces an element of uncertainty. Therefore instead of buying animals we have tried to make other arrangements. For example, a rabbit farm furnished us twenty-five young rabbits for $15.00. At the end of the year they collected these rabbits and returned them to the farm. This year they gave us twenty-five young rabbits. This arrangement will continue as long as the firm is in business, so it means that for the initial expenditure of $15.00 we shall have a new set of twenty-five young rabbits every year. We helped stock the school aquaria by getting about 400 small carp from the lake in front of the Art Museum.

Most of the pictures, charts, slides, movies and stuffed specimens, are furnished by the Educational Museum. This service is provided by

the Cleveland Board of Education and trucks deliver material ordered to each building on a bi-weekly schedule.

4. Time Allotment

Until a definite period of time is allotted to elementary science on a school schedule, the teaching of the subject is likely to be rather indefinite. This is just as true of schools built on an activity program as it is of schools working on a subject basis. The activities or subjects should be so planned that a certain portion of the day or week be devoted to those activities primarily stressing certain subjects or content. It does not seem fair either to the teacher or the pupil to leave this to the teacher's discretion. Then, too, a teacher is reluctant to devote much time to science, if by so doing she is encroaching upon the time set for other subjects.

In May, 1931, a new time schedule was adopted for the Cleveland Elementary Schools. The time allotted to Science in minutes per week is as follows: Kindergarten—25, First Grade—30, Second Grade—50, Third Grade—60, Fourth Grade—90, Fifth Grade—120, Sixth Grade—120. The same amount of time is given to science as to history.

The organization of the science curriculum in the individual school is interesting, but the evolution of the problem as a whole has been even more so. The extent to which the teaching of elementary science has permeated the entire system has been a fascinating phase of the work. As I said before, there were in the Cleveland elementary schools a few teachers who were teaching some science when the Curriculum School was established in February, 1928. In the fall of 1930, fifteen schools expressed a desire to do intensive work in science, so these schools coöperated with the Science Curriculum Center and, in this way, our experimental work was greatly extended. Many of the units studied in the science center were tried out in these schools under varying conditions.

At the opening of the next semester this group had grown to twenty-five schools. Many of these buildings now have a well-equipped science room and the minimum list of supplies. In the fall of 1931, about 95 per cent of the elementary schools were teaching science, and by the fall of 1932, all of our 117 elementary schools were teaching the science units in each grade as outlined for that grade.

In Cleveland, most of the elementary schools are organized on the departmental bases in the upper grades. We like this plan very much, as it gives the opportunity for each of the major subjects to be taught by one who knows and is interested in that subject. At present we have 177 departmental teachers of elementary science. Of this number, 116

are taking science courses and are becoming especially well-grounded in the subject. Ten teachers now have a Bachelor of Science degree.

In addition to the 177 departmental science teachers, there are 66 fourth- fifth- and sixth-grade teachers in buildings not on a departmental basis, and 872 first- second- and third-grade teachers, making a total of 1,115, teaching elementary science in Cleveland. There are, also, two teachers at the Museum of Natural History. Since they, too, are under the same supervision, an effort is being made to have the lessons at the Museum function very definitely in connection with the science units. Each elementary school is scheduled for four visits to the Museum during the year. These classes of fifth- or sixth-grade pupils are accompanied by the science teacher.

No doubt you are wondering how so many teachers could be developed to teach an entire science course of study within so short a time. We do not delude ourselves that this ideal has been attained, for it takes time for a teacher to become familiar with the material of a unit and to handle it well, so that the best learning situations are created for the pupils. It is bound to take longer to teach a unit the first or second time and, since we believe the method of teaching science is of paramount importance, we give the teachers time to develop these better methods through practice and experience. For these reasons we began with only a few required units for each grade. This year we added more required units. By next year, most of the units will be required. In this way, our course is evolving.

A question that confronts every supervisor is how to multiply good teaching. All of you have many ways of doing this. One that has proved very effective with us is the preparation of mimeographed copies of the units, containing definite material helps, references, tests, etc. We have about one-third of the course for each grade in mimeographed form. Next year, our plans are to have another third in mimeographed form, and to complete the work during the following year. Then we shall start anew with modifications and adjustments. When a new unit is presented to the teachers, we frequently have a talk by someone who is an authority or who is well-informed on the subject. Another means of improving science teaching is through demonstration lessons given by the better teachers in different sections of the city. To each of these are invited the teachers from twelve to fifteen schools in the vicinity of that building.

The first city-wide science test was given at the end of last semester. Reports were sent in from most of the schools, giving the results of at least one class in each of the third, fourth, fifth and sixth grades. These results are very gratifying as the city median is higher in every grade

than we had anticipated. Although these test results are not an absolute measure of the work done, yet unquestionably they reveal that thousands of boys and girls in Cleveland know many science facts and principles.

We have many plans for the future to improve the standard of science teaching in the elementary schools. We are trying to do something to prepare those who may become teachers of elementary science, when we shall have vacancies in those positions. Because of increasing the size of classes in the schools, and because few teachers are resigning, none of those who were graduated in the last two classes from the School of Education have received appointments in Cleveland as regular teachers. We selected eight graduates from the June, 1932, class who had majored in science and were ranked in the upper portion of their class. We call this group the "To be Science Teachers," and counselled with them in regard to continuing their study at least for part time, and suggested the science courses we thought would be especially beneficial. Whenever a science teacher is absent, one of this group of eight is called as the substitute to take her place. Such a plan gives these young people an opportunity to see many science rooms and to learn many things that science teachers are doing. From these they can form some idea of better ways of handling material as well as of teaching. Such a scheme enables these girls to earn a little more than the cost of the courses they are taking, and it keeps them encouraged and optimistic toward the future.

We are also preparing radio lessons in elementary science. Next fall we shall broadcast one elementary science lesson per week for the sixth grade. We aim that these shall be especially good lessons, for they will serve as another means of increasing good teaching.

We are fortunate in Cleveland to have two elementary school buildings equipped with a public address system and loud speakers in every room. These radio laboratory schools enable us to experiment with these radio lessons in various ways before broadcasting them to the entire city.

In conclusion, I hold no claim that this program of elementary science is perfect in every detail. I hope I have made it clear that there has been an effort to unify and coördinate the organization and carrying out of this project. We have tried to keep a well-balanced program and to prevent going off on tangents, and to hold in check hobbyists and those who are inclined to over-emphasize certain phases of science. We have tried to keep the growth of this science program normal and healthy.

It is our sincere hope that the curriculum and the teaching in the elementary-science department will never become static, that it will constantly develop and change, and that the changes, improvements, and modifications will continue to be founded on scientific research.

Learning General Science Through Projects*

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Into any discussion of teaching that concerns vital questions, the subject of the freedom of the child must enter. I propose to discuss the teaching of science, therefore, with particular attention to the matter of freedom. It is by means of an analysis of general science teaching which takes into consideration the need of the child for freedom that I shall reach a conclusion in favor of teaching general science by what I call group projects.

I shall introduce what I have to say concerning the value of freedom by describing a series of incidents which occurred in my home recently. My baby daughter has an ABC book which she is in the habit of bringing to me to read every evening after dinner. She climbs on my lap and looks at the letters and verses while I read them to her. I always ask her what the letter is that is written large at the top of a page. If she doesn't know, I say the letter and she repeats it. After we did this night after night for about two months she succeeded in learning the letters A B C D, but all letters after D were just "D." I would pronounce one of these other letters correctly to her, and she would say it after me, but as soon as I asked her again, "What is that letter?", she would say "D." This reading was a source of great delight to her, and she never failed to remind me of it after dinner. One evening I became impatient with her slow progress, and I decided to employ an active teaching technique. When we came to the letter O I asked her what the letter was, and she replied "D." I said "O." She said "O." I repeated my original question, "What is that letter?", and again she said "D." Then I slapped her on the leg and said quite sharply, "No, it is O." After I had slapped her once or twice more she learned to say "O." We turned to P, and she called it O. I slapped her leg until she said "P" consistently, and then I turned back to O, which she immediately called "P." After more slapping, she learned to say "O" again. We stopped reading at that point.

The next night she brought me her book as usual, climbed up on my lap, and when I pointed to the letter A, which she had formerly known very well, she called it "O." I corrected her sharply, but she persisted in calling it "O." Without reading further, I closed the book. Thereupon she took the book to her mother, who refused to read it to her. The baby then

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got a bird book and brought it to me. After we had finished reading it, I asked her to bring her ABC book, and she replied very decidedly "No, daddy." I did nothing about it, and the next evening she brought the book to me again, and again she called the letter A, "O." I corrected her as gently as possible and continued reading with her. She called most of the letters "O," and when we were about half through the book she quit and brought another book. That was the first time she had quit of her own accord before we had finished the book. To make a long story short, I managed, by being very gentle, to win her back to her book again after about a week. Then we had to continue her learning where it had been interrupted.

With older children I think the learning process is not so clearly blocked by a single incident of this sort. But the child in school is apt to be subjected to so many external pressures to make him learn, sometimes by the threat of physical pain and sometimes by the command of external authority, that his natural interest in learning is apt to be thwarted. Instead of teaching children arithmetic, I am afraid that we teach some of them to hate arithmetic. And we surely teach some of them to hate science. It is next to impossible to learn something that you hate.

All of you could add instances of this sort of thing from your own experiences. There can be no doubt of the value of utilizing the natural interests and enthusiasms and desire to learn of the children, nor is there any doubt of the danger that comes with forcing things on them. There are few psychological laws more firmly founded than the Law of Motivation. A person learns easiest and most quickly when he recognizes that the thing to be learned is in accord with his own interests and desires, and he learns very inefficiently if the thing to be learned is distasteful to him.

These facts, as well as others which I shall mention later, make it seem necessary that we include in our schemes of education a good deal of freedom which we justify mainly by our faith in the desire of children to learn, and our belief that they will learn if left free. I don't believe that we need feel insecure about building education upon faith. I have heard it said that a theory of education must be built either upon faith or upon postulates, and I am sure that postulates can lead us astray as well as faith can.

How far can this freedom go? There must be limits to the child's freedom, that is certain. Where shall they be set? That is one of the questions I shall attempt to answer—where shall the boundaries to student freedom be set in the general science course?

We have gotten some experience within the past year to help us

answer this question. Before speaking about this experience may I explain to you our situation at Ohio State University? The University High School opened last Fall with about 200 students divided among seventh, eighth, ninth and tenth grades. Science is a required subject during every year of our curriculum. The time devoted to science is not much more than that of one half of a full course, because a science class meets for two or three eighty-minute periods a week, and students are not required to make much preparation outside of the science periods. In addition to our regular class work in science we have had certain extra-curricular science activities which seem to have some significance for a discussion of freedom. It is this extra-curricular or "free-choice" science to which I referred when I said that we had learned something about freedom and I shall give a description of it next.

We started the year with a plan of allowing the child one or two periods each afternoon for what was called "free-choice" activity. Book clubs were formed, and writers' clubs, and dramatic clubs, a stamp club, a coin club, a photography club, and we threw open the science laboratories every afternoon for what we called "science experiments." Students were allowed to elect one or two or three from these and similar activities, the number depending upon the load of regular studies they were carrying. We found in science that something over one-half of the students in school were coming to our laboratory for a minimum of one 80-minute period a week, and a maximum of three such periods. Most of the students wanted to work in chemistry, though a group of younger boys wanted to work with electricity, and a heterogeneous group chose to work in biology. None of the students, who ranged from the seventh to the tenth grade, had worked in a laboratory before, though several of them had performed chemical experiments at home with simple chemical sets.

Our policy was to leave the students as free as possible. We teachers were in the laboratory merely to act as advisers and to prevent dangerous experiments. We prescribed the first day's work in the chemical laboratory—learning how to light a bunsen burner and how to cut and bend glass—otherwise we prescribed nothing. We placed a number of chemistry laboratory manuals in the chemistry room, and some biology and physics manuals in the other rooms. We wrote out directions for performing some simple chemical experiments and posted them on the bulletin board. Thus we provided suggestions for those that wanted them, but we gave almost no orders.

These are some of the things that we observed:

1. All children enjoyed their "science experiments" at first. It was a

novelty to them. It was apparently in many cases a matter of playing with new toys.

2. Some students became bored with the work after a few weeks. They sat and watched others work.

3. Most students preferred to find things to do on their own responsibility, rather than to accept suggestions from the instructors. A student would bring a little laboratory manual from his own chemistry set and perform experiments that he could not perform at home; he would find suggestions in a science magazine; he would perform experiments suggested in a Boy Scout manual; or he would turn the pages of a laboratory manual until a promising experiment caught his eye.

4. Students chose a number of different projects. There was not much tendency to imitate others. Usually there would be about ten different kinds of work going on among thirty children.

5. A large minority of the children showed a tendency to do the same thing over and over. Some of them would bend or blow glass one day after another. A few would perform one experiment several times without new departures. For example, three or four students distilled water several times.

6. Most students were very much absorbed in their work. Although somewhat disorderly in their attempts to get at an instructor for advice, they did this because of genuine interest.

7. There was very little reading done. Laboratory experience did not become a center from which the student radiated out by means of reading. We sought to encourage reading as a means of extending the meanings gotten in the laboratory, but with almost no response.

For various reasons, after about three months we changed our arrangement for free-choice activity, eliminating a large part of it from the afternoons and making Wednesday a "free-choice day" when every student could elect three activities. This change caused us to limit our group in science experiments to about fifty students. These are at present a somewhat selected lot, consisting mainly of children who had experience in the laboratory last fall and who know that they like it. They know where to find materials, and they handle apparatus with reasonable skill. The number of those who occupy themselves on the play level at bending glass or similar activity is small. However, even these selected people do not read as a result of their experiments. The experiments seem to be an end in themselves.

To illustrate the character of the work that was done by the more successful students during their free-choice time, the following list is given:

A mercury barometer, made by a seventh grade student.

Several simple telegraph sounders, made by younger boys.

A "machine gun," using compressed air to shoot beans out of a long tube.

Dissections of frogs, crayfish, clams, and a cat.

Microscopic study of protozoa, carried on by several ninth and tenth grade students.

Qualitative analysis of a piece of Arizona ore.

Qualitative analysis of solutions by means of flame tests.

Distillation of wood, coal, and crude oil.

Obtaining essential oils from various substances (cloves, cinnamon, etc.) by steam distillation.

Preparation of bacteriological culture medium and growing and staining of bacteria.

Before evaluating this kind of procedure, it would be wise to know about the experience of others who have tried to teach science by somewhat the same kind of method. I do not know where such a scheme of free-choice laboratory work is in use at the secondary-school level, though of course many teachers encourage a certain few students to carry on individual laboratory projects in their spare time. At the elementary-school level there is much more of a tendency to encourage individual projects. To mention those cases which I know about, Mr. S. R. Slavson has used something like this method for teaching science in the Walden School in New York and in the Malting House School in Cambridge, England, and Mr. Bruce Hinman has used a variation of it in his work with the elementary grades of the Ohio State University School. These men believe that children develop genuine scientific methods of work and thought when given freedom to work in such a situation. Mr. Slavson (though I believe Mr. Hinman would disagree with him here) has told me of his belief that at about twelve years of age a child who has had such a free experience with scientific apparatus will begin to want some rather formalized work. The child will want assignments and will be anxious to carry on a scheme of study which has some logical organization and requires reading and reflective thinking.

Taking account of the experiences I have related and the judgments of these other men who have worked with children on an elementary level, let us attempt to weigh the advantages and disadvantages of a method of teaching science at the junior-high-school level which gives children a good deal of individual freedom.

Let us consider the advantages first. We find the child, or at least some of the children, recognizing the free-choice activity as their own,

directed by them and in accord with their own interests, and making no demands upon them other then those evoked from within them. We find a child discovering problems that are real problems to him, and having to find methods of solving them which produce real solutions. We find the child avidly exploring the world about him, using the tools that the laboratory provides. We find some children learning to like science, when by other methods of teaching they might be learning to hate it. We find children developing responsibility and independence and originality.

The disadvantages are as follows. Projects will be started but never finished because they prove too difficult or because the child's interest lags. The tendency will be for a child to get into the habit of dropping projects before he has finished them. Experimental work will not be carefully done. It may be that the child's techniques will be poorer than they would be if we attempted to insist upon certain standards of performance. The school will become a place of disorder and confusion. All the strongest tendencies will be centrifugal. The larger the school or the larger the class the greater will be the confusion. Children will do what children have always done when left to themselves—they will become savages. If order grows out of such a chaos it will be the kind of order we find among primitive men—order inspired by fear of the strongest or craftiest man, and based on anything but civilized values. If given complete freedom, children will fail miserably to achieve the social qualities which we want them to develop. They will be bickering constantly instead of coöperating. They will be evading responsibility and allowing a few stronger persons to give orders. Furthermore, if we allow children complete freedom to choose the material they will study, we shall find them missing important things. Children at the junior-high-school age do not go naturally much below the surface of phenomena. They do not naturally look for the scientific relations which unite phenomena. The seeming variety of things in the world completely hides from them the fundamental unities. They are primarily interested in activity, in making things go, in seeing how things work. What we are disposed to call "real science," the study of relations between natural phenomena or the study of scientific laws and theories, is abstract and foreign to the concrete interests of children. It probably will remain foreign to them all of their lives, as indeed it does nowadays to most adults, unless they are guided to it by skilful teaching.

While we are discussing disadvantages let us sum up the disadvantages of the opposite method of teaching, that is, of external organization and direction of the child's activities. If the teacher channels the way

for a child and exercises external measures to induce him to follow the channels, the child may rebel, or at least he will be passive, failing to make use of the will to learn with which he is endowed. Self discipline and coöperation and responsibility are not assured by a teaching method which does not supply situations in which the ability of children to exercise these qualities is put to a test. If the teacher organizes the learning activity and the learning material in such a way as to teach "real" science—the generalizations and relations of science—the result is apt to be a barren verbal knowledge.

Hence we see that either the extreme of individual freedom or the extreme of teacher domination carries evils with it. Thus in science teaching, as in all of our teaching, we are faced with a dilemma. We recognize the necessity, if children are to earn effectively, of trusting their own natural interests and will to learn to carry them through much of their learning. But we also recognize that children need guidance. We know that when left to themselves children secure a very bad kind of education.

It is a real dilemma. One may take one side, or one may take the other. Or one may compromise. But compromise is no solution of a dilemma. There are no solutions of a dilemma. A solution of a problem is a definite thing. A compromise is simply a way out which recognizes that the problem is insoluble and suggests a way of making the best of the situation. It is impossible to achieve in a full degree all of the objectives of teaching. Some of the objectives are mutually exclusive. Hence we must choose compromises which seem to our wisdom, such as it is, to make for the best total outcome of teaching.

I think that the point concerning the necessity of compromise is worth emphasizing further. Let me illustrate by describing the dilemma in which nearly every one of us finds himself with regard to eating. Shall we stuff or shall we starve? It is a great thing to stuff oneself at the dinner table. There are distinct advantages. On the other hand it is fine to live very ascetically, eating almost nothing and thus keeping our minds and bodies alert. The great achievements of the human intellect were made on empty stomachs. What shall a man do about eating? What do we do about it? We compromise—stuffing on Sundays, perhaps, and starving when we have to write a speech. It is foolish to be doctrinaire or dogmatic concerning the value of one or another way of meeting such a difficulty which is fundamentally insoluble. We know that each man makes his own compromises, intelligently or otherwise, in the light of as many of his ideals or values as possible. He compromises between stuffing and starving, and his compromise is valid for him, though perhaps not for any other man.

For many people the word "compromise" has a bad odor, suggesting some sort of violence to one's conscience. A man knows a certain course to be the only right one, but he compromises and follows another course. Such is not the case here, where we have two opposite methods of teaching, both partly right and partly wrong, making a compromise between them necessary. Perhaps I should speak of "a synthesis of the good elements of both methods," instead of "a compromise between them."

If we are to be intelligent about the dilemma of science teaching, each teacher must make such a synthesis or compromise in the light of his objectives of science teaching, so as to secure the best possible achievement in terms of them. Now I am frank to say that I have no overwhelming respect for statements of objectives of science teaching. I have tried to make them, and I find them changing all the time. Finally, I have come to the conclusion that a statement of objectives is a means, not an end. And I have no more respect for it than I have for a spade or any other tool. But I shall make a statement of objectives of science teaching and then in the light of that statement I shall attempt to suggest an intelligent compromise between the two extremes of teaching methods that we have been discussing.

What are we trying to do in general science?

1. We are trying to help children get some understanding of certain functions of human living. The general education of a child should lead him to understand all the functions of living and science teaching has a particularly important part to play in helping the child to understand the functions of selection of foods and other necessary goods, production and distribution of goods, transportation, communication, provision for personal and community health, and the very important function of learning about the nature of the world one lives in.

2. We are trying to help children develop certain attitudes or tendencies—I might call them moral qualities. We want children to become independent, able to plan and carry on their own work, responsible and coöperative, able to work together for a common purpose. We want them to be favorable toward social experimentation, with a critical faith in the efficacy of scientific methods to improve human living. The development of these qualities is no less the responsibility of the science teacher than that of the social science teacher or the mathematics teacher.

3. We are trying to help children develop certain skills and abilities. We want them to develop the ability to use books; we want them to develop the ability to learn from sources other than books; we want them to develop the ability to organize their knowledge and put it in spoken or written form; we want them to develop the ability to manipulate tools

and apparatus effectively. Science teachers share with other teachers the responsibility for helping to develop most of these skills and abilities.

Accepting this statement of the objectives of general science teaching, let us approach the problem of effecting an intelligent compromise between the extremes of teaching method. In general, I think it may be said that the learning of subject matter is favored by a great deal of organization and direction on the part of the teacher. If the teacher is skillful he can avoid the impression of imposition of subject matter and he can partially enlist the interests of the student. When work is cleverly organized and directed by the teacher we have at best only fair motivation but we have good subject matter. Thus if we had only the subject matter objective—the one I have listed first—I believe we should find it wise to place most of the responsibility for organization of subject matter and direction of class activity upon the teacher.

However, our other two general objectives are not served as well by teacher domination of the learning situation. In order to secure coöperation as a quality we must give the class jobs in which the children have a real option between coöperation and failure to coöperate. We must allow children some opportunity to choose their tools, to choose their methods of organization, and to assume real responsibility if we are to help them develop these qualities and abilities.

Somehow we must provide enough freedom in our organization of science courses and in our guidance of science classes to leave room for the development of the attitudes and abilities which can thrive only in an atmosphere of freedom. The general kind of compromise which seems to me to be most satisfactory consists of a scheme of teaching which might be called a "group project."

There are two types of group projects. Clubs, such as Photography Clubs and Chemistry Clubs, are group projects formed by the appeal of some activity in which a number of people are very much interested. I think that a very good argument could be made for teaching science, and all other subjects, in clubs or voluntary organizations formed for the purpose of working at something of common interest. The trouble with this plan is that some students would have to be assigned to clubs which would thereby be turned into classes. The other type of group project, about which I wish particularly to speak, is that which can be carried on by the ordinary science class, composed of a heterogeneous group of students with or without strong interests in science.

The teacher assumes considerable importance in such a project. The question of how much direction he should exercise is a delicate one, with a different answer for each different teaching situation. The teacher

might, for example, outline the subject matter field to be covered during the year, or during the semester, and allow the class to organize its work for that period so as to cover the field assigned. But this would be giving too much freedom to most junior-high-school classes. The teacher would need to help in the organization of separate units of work, gradually shifting responsibility to the class as it learned to take responsibility. Within a given unit of work which a class takes on as a project there would be division of labor. Leaders would arise and assume the lead in various sub-projects. The group would learn to divide up the task and to work harmoniously toward a common goal. The success of the project would depend upon the teacher's ability to allow the children just the right amount of freedom. Too much freedom would result in aimless fooling on the part of students. Too much direction would arouse antagonism or leave the children indifferent to their work. In such a situation the use of textbooks as reference books rather than lesson books would be advisable. Students would be encouraged to arrange for the use of laboratories, excursions, and pictures. The group should have a voice in deciding the character of the testing program—in deciding the purpose and the scope of tests, and possibly in helping to make the tests.

This may seem to be a rather vague suggestion to come as the goal of so much discussion of science teaching, but I have very little more to say about the form a group project would take. It must not take any rigid form, since to be a genuine group project it must grow out of the particular combination of teacher, students, curriculum, and physical and social environment of the school. As I have said before, the group project is a compromise between two very definite but unsatisfactory extremes of teaching method, and it cannot be a unique thing which is defined once for all.

I shall come as near to a formal definition of a group project as possible by giving a list of the characteristics a group project should have.

1. The group plans its own work within the confines of a general plan provided by the teacher.

2. There is usually a division of labor—some members carrying on special work, the results of which will be reported to the group.

3. The group takes responsibility for enriching the textbook material by planning excursions and securing slides and films. The group aids in the task of describing its objectives and testing for their achievement.

4. The group may exist as a group only for the duration of a special project (as a Bird Study Club) or it may be a group which has accepted a long continuous task (as that of studying science together).

One thing I wish especially to warn you against is the conclusion

that I am advocating the "Unit Plan" under another name. I think there is a very important difference between a group project and a unit. During the last few years we have come to use the term "unit" variously, but I believe it is correct to say that the unit plan of teaching science, in all of its variations, is primarily and fundamentally a way of organizing subject matter. It is true that Morrison writes of an "appreciation" type of unit which is concerned with teaching attitudes similar to those I have suggested as objectives of our science teaching; but I believe that no one has succeeded in describing clearly a method of teaching attitudes by units, or of analyzing attitudes into their unit learning elements, or of testing for the mastery of these attitudes. We do, however, have the "science" type unit well developed as a scheme of organizing science type subject matter and we have added to it a notion of "mastery" with its resultant theory of testing. A group project differs from a unit in that it does not represent a particular theory of organization of subject matter. If I had to put the difference into a sentence, I should say that a unit is a certain way of teaching subject matter, while a group project is a way of teaching children. While the unit technique possesses many advantages, it is sometimes no better as a means of motivating students than the old logical organization of subject matter. A unit can be and often is forced upon a child just as externally and with just as much violence to his immediate interests and volitions as any chapter of a formal textbook would cause.

The unit method and the group project may be used together, and they seem to supplement each other, but one cannot take the place of the other. They are designed to secure results which, though different, are not incompatible. The group project would in all probability take the form of a unit, but with the following significant differences from the usual unit.

1. The group project would be organized largely by the students, and could not be forecasted in detail by the teacher.

2. The group project would not include teaching to the point of "mastery" except as students set up certain minimum requirements for themselves.

I shall summarize briefly the ideas I have attempted to state. We can teach general science most effectively for the realization of our aims if we succeed in getting some of the students' own drive enlisted in the choosing and planning of the material to be studied. The group project seems to present a workable means of enlisting children's interests and of helping them to develop some of the attitudes and some of the learning abilities which they should be acquiring.

The Talking Movie and Students' Interests

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The factor of interest in education is of no less importance and significance in our present educational philosophy than it has been in the past. Its importance was probably recognized before the time of Pestalozzi and the subject was not closed with the profound discussion by Dewey. The degree of a student's interest in a given activity is often of more worth to him in his future dealings with that activity than is his knowledge regarding it. His interest is of significance as well as his familiarity with it. Also, we learn that desirable activities of an extrinsic nature should be presented to the student with incentives to stimulate interests in these activities.[1] These incentives call into play an interest which exercised with satisfaction strengthens this interest, thus producing an effective learning situation.

With the introduction of the sound-motion picture as a new educational device, its value in stimulating interest on the part of the student was considered at once as one of its chief assets. Brodshaug and Strayer state, "Interest may readily be established at the outset by presenting a sound picture based upon the unit of instruction as an introduction to the teaching unit."[2] Tyson, in noting some of the observations of the practical value of talking pictures in visual education says, "One outstanding fact noted is that absolute attention and silence are given talkies but not silent films."[3]

A large group of educators in schools of education of eleven universities were shown an educational motion picture, reports Lewin.[4] He states that when they were asked for reasons why they were so delighted with the picture that, among other things, most of the teachers stated talkies were more interesting, more stimulating. In reporting the results of a rather comprehensive although poorly controlled experiment in the use of sound films in the schools of Middlesex, England, it is stated, "We have been impressed in analyzing the results of our experiment by the frequent evidence of heightened attention and interest shown by the children."[5]

These statements are mostly a matter of individual or group judgment. Some of them indicate a hope for a cherished idea; others are opinions based upon observations of immediate reactions by pupils or teachers viewing the films.

The Problem

In the investigation which is the basis of this report it was proposed to reduce to objective measurement the interest reactions of students who were subjected to the sound-motion picture used as an aid in classroom instruction. To what extent and in what particular manner are such pictures effective in developing and maintaining pupil interests in the activities included in the films? How do interests stimulated by the sound-motion pictures compare with student interests stimulated in the same activities when illustrated and presented with other types of visual aids? To what extent do such interests as stimulated by the talking movie as compared to interests stimulated by other visual aids carry over? To what degree are interests already possessed by the student in an activity maintained and heightened when that activity is presented to him in the classroom through the medium of the sound film as compared to the extent to which they are maintained and heightened when the activity is presented in other ways? These are the questions the answers to which were sought.

The Experiment Described

Approximately 600 students were the subjects of this investigation. These students were mostly college freshmen enrolled in a survey course of the physical sciences. The students' interest in scientific things was only a general one, their primary concern in their college career being to train themselves for business. The students were divided for experimental purposes into two groups, a control group and an experimental group of similar intellectual and educational development. With the experimental groups certain activities included in the regular outline of the course were presented through the medium of the sound-motion picture. With the control group the same activities were presented by lecture demonstrations identical with those in the films. Also, other activities included in the outline were presented to the experimental group with silent motion pictures, while the control group had lecture demonstrations identical with the activities shown in these silent films.

In addition to this direct comparison of the two groups having different types of visual aids another comparison was made. This consisted in showing certain other sound pictures to all the students, other silent films to all the students, and also, presenting to both groups other activities of the course by means of lecture demonstrations.

This allowed for three types of comparisons: first, sound films with lecture demonstrations through the same activities presented to the experimental and control groups; second, silent films with lecture demonstrations through the same activities presented to the experimental and

control groups; and third, a comparison of sound films, silent films and lecture demonstrations used to illustrate different activities but shown to all the students.

The demonstrations shown to the control group in place of the films were in all cases identical with the items shown in the films. For example, when the sound film "Characteristics of Sound" was used the demonstrations performed for the control groups consisted in filtering out certain frequencies of instrumental music, and vocal music and speech, reproduced in the classroom, with electrical apparatus, thus showing and explaining the effect of removing some of the frequencies of sound waves. These were the experiments shown in the film.

In this study five sound films and five silent films were used. These constitute a sampling of the best films relating to the subject matter of this course which are at present available. In this connection it is to be noted that the scarcity at present of satisfactory educational sound films constitutes a serious difficulty in a comprehensive study of their merits and uses as an aid in classroom instruction. The sound pictures used are of the type in which the sound is a vital and realistic part of the picture. When an explanation is made the speaker appears in the picture and is working with the objects talked about. Also, all sounds which are natural to the scenes shown are reproduced by the film. For example, in the film "Radio-active Substances," when Dr. Hewlett holds a piece of radioactive material in front of the ionization chamber of the Geiger counter, the sounds produced in the loud speaker of the apparatus, each sound representing an atom disintegrating, are also reproduced by the film. The sound in this type of film has the effect of being a vital part of the picture and not a speaking voice accompanying the scenes presented.

The films used in this study and their producers are shown in Table I.

Objective Measurement of Interests

The measurement of interests has received considerable attention in the past. Particularly is this true with regard to vocational interests. Such studies of significance have been made by Freyd,[6] Ream,[7] and Cowdery.[8] In the field of measurement of educational interests are the important studies made by Kelley,[9] King,[10] and Franklin.[11] Tests were used by these investigators to measure and record interest reactions. The practice followed in designing and perfecting all these interests tests was to have the test consist essentially of a comprehensive questionnaire in which the subject is asked to record in a variety of ways his choice of first interest.

TABLE I

MOTION PICTURE FILMS USED TO STUDY THEIR EFFECTIVENESS IN MAINTAINING AND STIMULATING INTERESTS WHEN USED AS AIDS IN CLASSROOM INSTRUCTION

Name	*Subject*	*Kind of Film*	*Producer*	*Students Having Film*
Characteristics of Sound	Sound Quality of Music and Speech	Sound	E.R.P.I.	Experimental Group
Liquid Air	Properties of Liquid Air	Sound	Ceneral Electric Co.	Experimental Group
Radio-active Substances	Structure of Atoms	Sound	General Electric Co.	Experimental Group
Wizardry of Wireless	Transmission and Reception of Radio	Silent	General Electric Co.	Experimental Group
Revelations by by X-rays	Production and Properties of X-rays	Silent	General Electric Co.	Experimental Group
Electromagnetism	Electric Generators and Transformers	Silent	Carpenter Goldman (Special edition)	Experimental Group
Story of a Gasoline Motor	Working of Automobile Motor	Silent	U. S. Bureau of Mines	All
Stepping Ahead	Color in Light	Sound	National Lamp Co.	All
Across Cont. in 48 Hours	Airplane Transportation	Sound	Visugraphic Pic. Inc.	All
Eclipse of 1925	Suns Total Eclipse	Silent	Pathe	All

Two methods were used in measuring interests in the present investigation. One method was to use an interest test, based upon the activities tested, and constructed upon the same fundamental principle employed in the instances cited above. A test of twenty statements including eighty different items was prepared. The test was given to the students twice, at the beginning of the study and again five months later, after the students had had the advantages of the films and demonstrations. The change of choices in the second taking of the test is taken as a measure of the effectiveness of these types of visual aids in stimulating new interests while the consistency of choices in the second taking of the test indicates the effectiveness of the visual aids in maintaining and heightening an interest.

The second method used in measuring interest was based upon the consideration that the extent of the sustained attention of the student is indicative of the immediate interest which he has in the topic being presented. The method employed a distracting stimulus and the photographic technique to measure the extent of this sustained attention. That the degree of attention manifested is indicated by attentive behavior which can be measured objectively by measuring motor responses is the thesis involved in this measurement of sustained attention of the students as stimulated by sound films, silent films and lecture demonstrations.

The distracting stimulus was provided by a ringing bell or a flashing light at a point in the room different from the point on which the students' attention was being focused by the motion picture or lecture demonstration. The number of students who were distracted was determined by photographing the class after a sufficient reaction time following the stimulus. The photographic apparatus was mounted in the front of the classroom. The entire apparatus was electrically operated so that the instructor could produce the distracting stimulus and photograph the class at any instant by pushing a single control button. The number of students who were distracted was determined by counting, in the photograph, the students who had looked away from the center of attention.

Results

Two kinds of analyses of the data from the interest test were possible. One had to do only with the students' choices of those items which were presented in the classroom by using sound films or silent films with the experimental groups and demonstrations with the control groups. The other had to do with all the items of the test, even though some of the items were demonstrated to all the students by either sound films, silent films or lecture demonstrations. Both analyses were made. The result of the first analysis is shown in Table II and Table III.

In comparing sound films with demonstrations there was a persistency of interest of 59.9 per cent for sound films indicating to this extent their relative effectiveness in maintaining initial interests, as against 54.9 per cent for identical lecture demonstrations, indicating to this extent their relative effectiveness in maintaining such interests. This difference in favor of the sound films is believed large enough to be significant. There was a change to the variable items of 27.4 per cent of the choices by students having the sound movies as compared to 22.2 per cent by students having identical demonstrations. This is a specific indication of the stimulation of new interests to this relative extent, and

TABLE II

NUMBER AND PER CENT OF PREFERENCES FOR ITEMS ILLUSTRATED TO EXPERIMENTAL GROUPS WITH SOUND FILMS AND TO CONTROL GROUPS WITH IDENTICAL DEMONSTRATIONS

Nature of Preferences	*Experimental Group Having Sound Films*	*Control Group Having Identical Demonstrations*
Number of Initial Preferences for Variable Items	482	744
Number of Initial Preferences Made for Items other than Variable Items	1119	1870
Number of Preferences of No. 1 above Which Did not Change	289	409
Per cent Which Did not Change Preference	59.9	54.9
Number who Changed Preference to Variable Item	307	415
Per cent Who Changed Preference to Variable Item	27.4	22.2

TABLE III

NUMBER AND PER CENT OF PREFERENCES FOR ITEMS ILLUSTRATED TO EXPERIMENTAL GROUPS WITH SILENT FILMS AND TO CONTROL GROUPS WITH IDENTICAL DEMONSTRATIONS

Nature of Preferences	*Experimental Group Having Silent Films*	*Control Group Having Identical Demonstrations*
Number of Initial Preferences for Variable Items	1145	1036
Number of Initial Preferences Made for Items other than Variable Items	1359	1193
Number of Preferences of No. 1 above Who Did not Change	767	694
Per cent Who Did not Change Preferences	66.9	66.9
Number Who Changed Preference to Variable Item	356	319
Per cent Who Changed Preference to Variable Item	26.7	26.2

again the difference in favor of the sound films is large enough to be significant.

Similar comparisons of silent films and lecture demonstrations as given in Table III fail to show an advantage of either the films or demonstrations in maintaining previous interests or stimulating new ones.

The result of the second kind of analysis of the data from the interest test is shown in Table IV. This analysis was of the complete data from the test. The per cent of preferences which remained unchanged, indicating the relative effectiveness in maintaining and heightening interests already possessed by the students of the three types of teaching aids, is shown in Table IV.

The difference between the effectiveness of the sound films and the

silent films is inconsequential. However, the difference between these two forms of visual aids and classroom demonstrations is probably large enough to be significant.

TABLE IV

INITIAL AND FINAL INTEREST CHOICES OF ITEMS ILLUSTRATED DURING THE EXPERIMENT BY LECTURE DEMONSTRATIONS, SOUND FILMS AND SILENT FILMS

Preferences	*Demonstrations*	*Sound Films*	*Silent Films*
1. Total number of initial first choices of test items made	9,389	9,389	9,389
2. Number of initial preferences for items illustrated later by	5,762	2,152	1,475
3. Number of preferences of No. 2 above which were not changed	3,149	1,277	890
4. Per cent of preferences which remained unchanged	54.6	59.4	60.3

The results of measuring the sustained attention of the students in the presence of a distracting stimulus when looking at sound films, silent films or lecture demonstrations are given in Table V.

TABLE V

SHOWING NUMBER AND PER CENT OF STUDENTS WHOSE ATTENTIONS WERE DRAWN AWAY BY A DISTRACTING STIMULUS FROM A SHOWING OF SOUND FILMS, SILENT FILMS AND LECTURE DEMONSTRATIONS

Visual Aid Used	*Total No. Pictures Made*	*Total No. Students Pictures*	*Total No. Distracted*	*Per cent Distracted*	*Per cent Maintaining Attention*
Lecture Demonstration	12	643	292	45.4	54.6
Sound Motion Picture	15	813	149	18.3	81.7
Silent Motion Picture	8	426	106	24.8	75.2

It is to be noted that 54.6 per cent of the students who were taught with the lecture demonstrations method of visual instruction maintained sustained attention under a given distraction while 75.2 per cent of the students taught with the aid of the silent motion picture maintained sustained attention under identical conditions of distraction and 81.7 per cent of the students instructed with the aid of sound pictures, maintained such attention under the same conditions of distraction.

Conclusions

In forming conclusions regarding the results of this experiment it is important to keep clearly in mind the essential features of the problem. How effective in relation to other widely used visual aids is the sound motion picture in stimulating, maintaining and developing interests on the part of students in a given activity? If a new educational device is to supplant older and established ones, the new device must possess an advantage over the others in present use which justifies the change. To produce sound pictures for classroom use requires educational skill, highly specialized equipment and engineering ability. To reproduce the picture in the classroom is still an expensive and somewhat technical process. Do the educational talking movies possess an advantage over the silent films, or the actual activity carried on in the classroom, which would justify their wide use?

It is to be questioned that the educational sound film is superior to the silent film with printed captions in imparting information to the student. Particularly is this true, if the sound film consists only of a lecture imposed upon a silent film from which the captions have been removed.[12] The question, therefore, concerning the effectiveness of the sound films in affecting interests is of importance. The results of this study show clearly that such films can be used effectively as a means of arousing interest preparatory to teaching, and in strengthening interests previously acquired. Also, they suggest that sound films of the kind used here are more valuable, in this respect, than are the silent films, or the objects themselves.

The explanation of this suggested superiority of the sound films must be one of two main causes. First, it is that the sound film represents inherently the best educational device for presenting activities to the student in such a way as to challenge and stimulate his interests. If this be true it constitutes a significant and important new educational development. The other is that the sound pictures in the classroom are at present a novelty, and therefore, interesting; and that the student is accustomed to seeing the sound pictures in the theatre as an improved means of entertainment over the silent film. In either case, to stimulate this interest the educational sound film should be produced with a high degree of educational skill and reproduced in the classroom with the same technical excellence as that of the theatre.

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A Critical Analysis of Pupil Responses to the Concepts of Mechanics in High School Physics*

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Summary of Findings

The efficiency of learning in mechanics is very low as shown by this investigation. Of the total 895 exercises or parts of exercises, 561 (62.6 per cent) had a per cent of error of fifty or more; and 293 (32.7 per cent) had a per cent of error of seventy-five or more.

Significant differences do not exist between the achievement of pupils using one textbook and pupils using another of the four considered.

The exercises in the drills discriminate between pupils in the first and fourth quartiles; fifty per cent of the exercises having an "index of goodness" over 3.00.

Even though there were many different wrong responses recorded to a large majority of the exercises, for 42 per cent of the exercises there were dominant errors which comprised a large per cent of the errors made to that particular exercise.

The pupils exhibit practically complete confusion on those exercises which do not have dominant errors but which have a high per cent of error. Pupils have many misconceptions which deal with mechanics and measurement.

The following summary has been made of the inabilities and misconceptions which pupils have shown in working the drills. In order that these statements may be more meaningful, quantitative data are included. These statements concerning misconceptions have been based upon pupils' attempts since omissions, although considered an error, represent a lack of conception rather than a misconception. The number of pupil attempts, the number of errors, and the per cent of error based upon the pupil attempts will be given for each statement.

A. MATHEMATICS DIFFICULTIES

1. Pupils are unable to make very simple numerical computations. Of 1681 errors made on simple numerical problems on 17 exercises of Drill 1 there were 357 (21.2 per cent) errors, distributed as follows: 84 errors

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in multiplication, 34 errors in addition, 93 errors in division, 2 errors in subtraction, 124 errors in decimals, 105 errors in choosing the proper process to use in the particular situation. Of these 105 errors in the selection of process, 61 were division when it should have been multiplication.

The data on the analysis sheets show that the numerical problems in the other drills cause similar confusion in the minds of the pupils.

B. Measurement

1. That pupils do not know the metric units of measurements may be seen from the large number of different wrong responses made to the exercises involving metric measurements. For example, the number of different wrong responses for exercises 3, 4, 6, 8, 10, 91, 13, and 18 of Drill 1 is 62, 9, 32, 35, 25, 22, 28, 30, and 80 respectively. Specific errors made to one exercise show that of 56 errors, 31 (55.2 per cent) were "100 grams equal 1 kilogram;" and 18 (32.0 per cent) were "10 grams equal 1 kilogram." For another exercise, of 83 errors, 20 (36 per cent) were "100 cc equal 1 liter;" and 12 (14.4 per cent) were "10 cc equal 1 liter." Similar confusion exists on other exercises which involve metric units, as may be seen from the analysis sheets.

2. The large number of different responses and the high per cent of error provides data for the conclusion that a large per cent of the pupils are unable to make simple numerical computations, are unable to use the fundamental processes correctly, do not analyze the problems, and are unable to state the units in which the answer is to be expressed. The analysis sheets of all exercises involving numerical computations reveal similar errors.

3. That pupils are unable to convert metric units into British units, and vice versa, may be seen from the per cent of error for these exercises involving such a conversion. For example, in Drill 1,

Exercise	*Per cent of of error*	*Total No. of errors*	*No. of different error including omissions*
7	49.5	162	81
9	56.5	180	84
14	84.4	276	63
15	62.3	204	94
16	81.6	267	127
17	78.2	256	58
19	69.1	226	68
20	78.5	257	87

The high per cent of error and the large number of different wrong responses clearly indicates that pupils are unable to make these conversions.

One of the main reasons why pupils do not make these conversions or solve numerical problems correctly is that they do not apply their laboratory or past experience to the solution. To Exercise 9, Drill 1, "A man 6 feet tall is how many meters tall?", there were 130 wrong responses of which 56 (42.6 per cent) were 3 meters or more, while 28 (21.3 per cent) of these wrong responses ranged from 18 meters to 290,464 meters. Application of laboratory experience would show a pupil the absurdity of these responses. Another similar illustration is seen in Exercise 17, Drill 1, "A tire weighs 12 kilograms. How many pounds is this?", for which wrong responses (20.5 per cent) range from 120 lbs. to 134,400 lbs.

4. Pupils know certain constants or approximations of constants, but do not know what units they express. For example, the number of inches in a meter as used in the drills is 38, 30, 37, 5, 100, 95, 38.5, 36.4, 32, 29.37, 37.2, 37.36, 37.35, 37.34, 10, 13, and various approximations between 39 and 40. Other British equivalents for the meter were 7 ft., 3 ft., 1.8 ft., 1/10 in., 1.39 ft., 2 ft., 4 ft., 13 ft., 1/3 ft., and others. These responses involving conversion factors indicate a lack of working master of units which must be used constantly in measurements and approximations.

C. VOCABULARY

Pupils are unable to differentiate between the concepts involved in the following pairs of words. The words are arranged in order of per cent of error based upon the pupil attempts. For example, pupils are confused with the difference of meaning of input and output, or possibly do not know either. Of the 1613 pupil attempts involving this pair of words, 847 (52.5 per cent) were inaccurate. Other numerical data are similarly interpreted.

		Attempts	*Errors*	*Per cent*
input	output	1613	847	52.5
velocity	momentum	442	228	51.5
energy	motion	277	115	41.5
malleability	ductility	229	123	41.1
molecule	atom	967	390	40.3
porosity	impenetrability	276	105	38.0
centrifugal	centripetal	565	206	36.4
force	pressure	1513	551	36.4
acceleration	motion	313	110	35.1
velocity	acceleration	555	187	33.6
specific gravity	density	1292	421	32.5
resultant	equilibrant	1449	468	32.2
energy	weight	92	28	30.4
acceleration	momentum	762	222	29.1
efficiency	mechanical advantage	1872	544	29.0

		Attempts	*Errors*	*Per cent*
force	acceleration	659	189	28.6
potential	kinetic	2739	763	27.8
neutral equilibrium	stable equilibrium	2253	602	26.7
adhesion	cohesion	823	214	26.0
inertia	momentum	311	76	25.0
resultant	component	2053	509	24.7
moment	mechanical advantage	308	69	22.4
sublimation	diffusion	909	201	22.1
energy	efficiency	64	14	21.8
energy	friction	64	13	20.3
force	inertia	792	161	20.3
dyne	erg	904	183	20.2
stress	strain	1433	288	20.0
force	velocity	676	135	19.9
dyne	gram	639	115	17.9
inertia	gravitation	176	31	17.6
energy	power	625	109	17.4
dyne	power	470	82	17.4
energy	mechanical advantage	64	11	17.1
molecule	electron	646	110	17.0
sublimation	osmosis	283	47	16.6
erg	power	470	75	15.9
dyne	poundal	587	89	15.1
work	momentum	613	86	14.0
erg	joule	281	37	13.1
inertia	impenetrability	310	40	12.9
sublimation	condensation	772	96	12.4
moment	input	308	38	12.3
energy	reaction	316	39	12.3
energy	momentum	400	49	12.2
force	energy	1568	189	12.0
surface tension	cohesion	797	95	11.9
center of gravity	center of oscillation	313	37	11.8
inertia	reaction	397	46	11.5
diffusion	adhesion	275	31	11.2
dyne	joule	317	35	11.0
capillarity	adhesion	876	95	10.8
stable equilibrium	unstable equilibrium	1247	129	10.3

D. Principles

	Attempts	*Errors*	*Per cent*
1. Angular forces			
a. Pupils do not know the difference between composition of forces and resolution of forces.	572	179	31.2
b. Pupils add, subtract, and average angular forces in order to compute the resultant.	1636	446	27.2
c. Pupils divide a force by two in order to obtain two components.	412	251	60.9
2. Principle of work			
a. Pupils think that simple machines reduce the amount of work reqired to move objects.	560	309	55.1
b. Pupils are confused on input and output.	1613	847	52.5

	Attempts	*Errors*	*Per cent*
c. Pupils think work is done by a force even though the force does not move.	304	59	19.4
3. Pressure in fluids and transmission of pressure through fluids. Pascal's law.			
a. Pupils think that pressure is not transmitted through a gas.	602	145	24.0
b. Pupils think that pressure does not vary directly as the depth.	323	50	15.4
c. Pupils think that pressure varies inversely as the depth.	1547	397	25.6
d. Pupils think that depth does not affect the pressure.	901	263	29.1
e. Pupils think that pressure varies as the volume or quantity of water.	959	189	19.7
f. Pupils think that pressure depends on the area and shape of the container.	1900	515	27.1
g. Pupils think that pressure and force are identical.	1513	551	36.4
h. Pupils identify this as Boyle's law.	1408	533	37.8
i. Pupils think that more pressure is exerted downwards from a point in a liquid.	964	159	16.4
j. Pupils think that pressure in a liquid varies inversely as the density.	1271	143	11.2
k. Pupils think pressure is transmitted through a liquid in proportion to the diameter rather than to the areas of the pistons.	2119	933	44.0
l. Pupils do not know that the total force exerted by a liquid depends on area, height, and density. One of the three factors is omitted.	1685	316	18.7
m. Pupils do not know that areas of circles are in the same proportion as the squares of their diameters.	2088	1042	49.9
4. Archimedes' principle			
a. Pupils think that buoyancy depends on weight or density rather than volume of object submerged.	595	392	65.8
b. Pupils do not think that a floating object displaces its own weight in a liquid.	1963	604	30.7
c. Pupils think that a hydrometer sinks deeper in a heavy liquid.	1293	371	28.6
d. Pupils are confused on the application of Archimedes' principle to air.	2275	807	35.4
e. Pupils do not know the difference between specific gravity and density.	1292	421	32.5
f. Pupils are much confused concerning Archimedes' principle as shown by the many different errors; the range of different number of exercises being from 1 to 76 with 22 as the mean for 33 exercises involving concepts dealing with flotation, buoyancy, and specific gravity.			
5. Energy			
a. Pupils are unable to differentiate between potential energy and kinetic energy.	2739	763	27.8
b. Pupils are confused concerning transformation of energy.	1437	739	51.4

	Attempts	*Errors*	*Per cent*
c. Pupils are confused concerning conservation of energy.	1058	755	71.3
6. Capillarity			
a. Pupils think that the height varies directly as diameter of tube.	686	414	60.3
b. Pupils think that mercury rises in capillary tubes.	751	315	41.9
c. Pupils think that liquid which moisten capillary tubes are depressed.	707	200	28.2
7. Simple machines			
a. That pupils are much confused concerning simple machines is shown by the large number of different errors made to the exercises involving concepts dealing with simple machines.			
b. Pupils do not know that the six simple machines may be classified in two classes, levers and inclined planes.	438	104	23.7
c. Pupils are unable to compute mechanical advantage from ratio of resistance to effort or from ratio of distrnce effort moves to distance resistance moves.	403	639	45.5
d. Pupils are unable to solve simple problems on simple machines.	2983	4142	51.8
e. Pupils do not know the difference between mechanical advantage and efficiency.	1872	544	29.0
8. Inertia, momentum, and reaction			
a. That pupils are much confused concerning these concepts is shown by the larger number of different errors and the lack of dominant errors.			
9. Density			
a. Pupils use: $\text{density} = \frac{\text{volume}}{\text{weight}}$	1150	341	29.6
b. Pupils cannot differentiate between density and specific gravity.	1292	421	32.5
10. Moment of force			
a. Pupils are unable to use moment of force in connection with levers.	1813	695	38.3
b. Pupils are unable to use moment of force in connection with parallel forces.	1840	586	31.8
c. Pupils confuse input and output with moment of force.	590	281	47.6
11. Uniformly accelerated motion			
a. Pupils do not know the difference between uniformly accelerated motion and uniform motion.	1250	687	54.9
b. Pupils think that total distance in uniformly accelerated motion varies directly as time.	600	325	54.1
c. Pupils think that velocity in uniformly accelerated motion varies as square of distance.	510	277	54.3
12. Air Pressure			
a. Pupils think that a vacuum or suction and not air pressure holds liquids up in exhausted tubes.	2470	670	27.1
b. Pupils think that the siphon does not depend on air pressure.	293	36	12.0

	Attempts	*Errors*	*Per cent*
c. Pupils think that the siphon can be used to raise liquids from a lower to a higher level.	310	116	37.4
d. Boyle's law			
1. Pupils think that pressure has no effect on the volume of confined air.	801	38	4.7
2. Pupils think that volume varies directly as the pressure.	2072	473	22.8
e. Pupils are confused concerning the fact that density of gas varies directly as the pressure.	620	165	26.6
f. Pupils think that air pressure increases with altitude.	1976	304	19.9
g. Pupils are confused with the fact that air has weight.	1214	326	26.8
13. Pendulum			
a. Pupils think that the period depends on bob.	889	183	20.5
b. Pupils think that the period depends on amplitude.	575	315	54.7
c. Pupils think that the period varies directly as length.	944	398	42.1
14. Gravitation			
a. Pupils think that the earth's attraction for objects is the same in all localities.	319	77	24.1
b. The many different errors recorded to the exercises involving concepts on gravitation indicates much confusion in the minds of the pupils.			
15. Kinetic Theory			
a. Pupils think that molecules may be seen.	326	146	44.7
b. Pupils think that molecules are farther apart in solids.	318	185	58.1
c. Pupils are unable to differentiate between an atom and a molecule.	967	390	40.3
16. States of matter			
a. Pupils do not know that solids have definite shape and definite volume.	978	330	33.7
b. Pupils do not know that liquids have definite volume.	1452	337	23.2
c. Pupils do not know that gases have neither definite volume nor definite shape.	1610	231	14.3
17. Hooke's Law			
a. Pupils think that strain is inversely proportional to the acting stress.	321	59	18.3

E. Identification of Laws and Discoverers of Laws

Pupils are unable to identify the discoverer of a law with the law. It does not seem to matter what the question, provided it calls for the name of some physicist, i.e., the discoverer of some principle, the names, Newton, Hooke, Henry Torricelli, Boyle, Pascal, and Archimedes will appear as the response.

From the following tabulation it is evident that pupils have not identified principles and laws with the name of the discoverer.

	Attempts	*Errors*	*Per cent*
1. Archimedes' principle was accredited to			
Newton	312	55	17.6
Hooke	622	94	15.1
Pascal	909	129	14.1
Torricelli	622	80	12.8
Boyle	1131	68	6.0
2. Pascal's law was accredited to			
Boyle	1845	477	25.8
Newton	323	53	16.4
Archimedes	2183	229	10.4
Torricelli	320	33	10.3
Hooke	826	109	13.1
von Guerricke	643	59	9.1
Charles	272	13	4.7
3. Boyle's law was accredited to			
Galileo	270	58	21.4
Pascal	1508	227	15.0
Henry	291	38	13.0
Torricelli	584	70	11.9
Newton	441	37	8.5
von Guerricke	270	11	4.0
4. Henry's law was accredited to			
Boyle	517	167	32.3
Lenz	189	26	13.7
Newton	189	25	13.2
Pascal	517	61	11.7
Charles	147	14	9.5
5. Hooke's law was accredited to			
Henry	452	171	37.8
Newton	719	76	10.5
Boyle	580	52	8.9
Pascal	184	12	6.5

Conclusions

The data reveal that the efficiency of learning in mechanics is low. The evidence which indicates this low efficiency of learning is:

(1) The inability of pupils to make simple numerical computations necessary to solve problems;

(2) The inability of pupils to show learning adaptations of the metric or British systems of measurements;

(3) The inability of pupils to apply past or laboratory experience to the solution of problems;

(4) The inability of pupils to differentiate between the meanings of technical vocabulary terms;

(5) The inability of pupils to show a comprehension of concepts or principles as a whole;

(6) The inability of pupils to analyze the problem or exercise before attempting a solution.

The incorrect responses of pupils to certain principles of mechanics reveal the fact that many misconceptions are of a similar nature. These similar misconceptions or dominant errors indicate some inherent difficulty in the particular concept to which they were given as a response. The elimination of these dominant errors would materially increase the efficiency of learning.

Educational Implications

1. The data reveal the need of remedial mathematics drills to be given in order that pupils may solve simple numerical problems involving the concepts of mechanics.

2. The data show that vocabulary drills should be developed and administered in order that pupils may become familiar with the technical vocabulary peculiar to physics so that they can read with comprehension the learning materials. The technical vocabulary is a tool of fundamental importance, which should be acquired by the pupil if he is to study physics effectively.

3. The data reveal that learning evercises designed to give understanding of principles need to be devised. Pupils often fail to comprehend the meaning of principles or sentences when the meaning of each individual word is known. This difficulty involves rationalizing the thought as a whole rather than knowing the meaning of individual words.

4. The data suggest that if pupils are to be able to respond correctly to these concepts some type of maintenance program should be devised to give pupils the opportunity to apply the concepts frequently enough and in sufficiently varied situations to provide for delayed recall and use.

5. The data provide dominant errors which may be used in reorganizing the physics curriculum, in the development of procedures for use during the learning period, and in the construction of tests.

6. The data indicate that the mechanics content, as represented by these 152 concepts, is too comprehensive to be learned in twelve to fourteen weeks. Either a selection of content should be made, or the time allotment extended.

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An Experimental Study in Integrating Testing With Learning in Biology*

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For many years the writer has been interested in means and devices for individualizing pupil response in classroom discussion or recitation in his course in tenth-year high-school biology. He has felt that many individuals, like sponges, would absorb the factual material by being good listeners to such discussion rather than developing and growing in student ability by learning to discover for themselves under teacher direction and stimulation. In his opinion, the most important and the most valuable lesson for adolescent pupils to learn is that of educational self-dependency, or the development of the ability of "learning to learn" in an independent way. By utilizing the time which would ordinarily be given over to classroom recitations and discussions for organized periods of supervised study, the opportunity is afforded of giving individualized instruction and assistance to students while active with their learning exercises. The writer has thus endeavored to place the responsibility of the student's learning squarely on the shoulders of each pupil, with a consequent checking up of results through end tests and the grading of assignments as each unit is completed. Certain other learning exercises are also assigned, the doing of which (under the philosophy of learning by doing) is the all important thing. Among these learning exercises are the so-called "practice tests" which became the experimental factor in the experiment about to be discussed.

Through means of control groups taking the identical end-tests and under the same teacher utilizing the same teaching methods but without the application of these practice-tests, certain objective data were obtained and are herewith submitted to substantiation of the theory that such self-scored test exercises do stimulate and increase pupil learning. Likewise it seems very probable from the experiment that such practice-tests are of considerable diagnostic and remedial value to the individual student, helping him in developing that much to be desired attitude and ability of self-dependency. As administered these self-testing exercises helped to enable each student to check up on his own learning and control of the subject matter and thus the tests became the pupil's tests and not the teacher's tests. As is readily apparent each pupil was called to respond

* A résumé of a M.A. thesis at University of Southern California, June 1932.

to each and every question. This practice greatly individualized the class recitation activities. The recitations became written exercises but, since each student corrected or scored his own paper or that of his neighbor, the teacher's task of ceaseless correcting of papers was eliminated. The results show that the pupils gained or increased their learning through the activity. Likewise questionnaire replies from the pupils indicated that they regarded these practice-tests as very valuable and helpful to them individually in a great many ways.

Under the stimulating influence of C. A. Buckner of the University of Southern California Summer Session staff, the writer made a preliminary tryout of the effect of student-scored and unrecorded practice-tests on pupil achievement in tenth-grade biology, as measured by certain teacher-prepared objective-type tests. The results were so positive and intriguing that it was decided to gather experimental data covering several units, comparing the scores made in identical tests, by the 1930–1931 classes, (the control group) with the marks of an equivalent 1931–1932, (the experimental group) upon which this one variable factor of practice-tests was applied.

The comparative scores of the number of errors made were collected for fine units extending in time over about two-thirds of one semester. Without any manipulation the 1931–32 group "fell" almost identically equivalent as to mental ability with the 1930–1931 students when the intelligence quotients, as determined by the Terman Intelligence Tests, were considered. Eighty-nine pupils of the experimental group had a mean IQ of 106.11, with a standard deviation of 13.08, while the control group mean was 105.52. Its standard deviation was 12.92 for eighty-eight boys and girls. The critical ratio of 0.03 indicated an equivalent satisfactory for the purposes of this study with a slight difference favorable to the students of the previous year.

An adaptation of Table XI of the original study which summarizes the experimental evidence obtained is herewith given as Table I. The increase in achievement in this case can be explained only as a result of training or conditioning in more analytical study methods. On the whole, total mean improvement of 14.06 for the four units showed a critical ratio of 2:30 which indicated chances of 92.4 to 1 that the increase in scores was real and that 98.93 per cent of such cases would, under identical treatment, show differences favorable to the group using the practice test.

Although these figures are not statistically certain they do show evidence closely approaching that value of 2.78 in critical ratio which means positive significance.

Table I

Recapitulation of Statistical Data Comparing the Experimental and Control Groups in Each Unit

Unit Chap.	*Mean 1*	*Mean 2*	*Diff. of Means*	*SD1*	*SD2*	*Diff. of SD's*	*SD of Diff.*	*CR*	*Chances to 1*	*Per cent above 0*
19	28.45	23.00	5.45	16.98	15.94	1.44	2.45	2.33	75:1	98.7
3	17.32	14.89	2.43	12.09	12.01	0.08	1.81	1.34	10:1	91.0
4	17.65	12.92	4.73	9.02	10.44	1.42	1.15	4.13	53000:1	99.9
6	16.21	14.76	1.45	10.29	7.35	2.85	1.13	1.29	9:1	90.3
7	13.88	12.20	1.68	7.21	7.42	0.20	1.10	1.53	14.5:1	93.6
Totals of first four units			14.06				6.54	2.30	92.4:1	98.9

At the close of the study a questionnaire was submitted to the students as to the benefits, if any, derived from the procedure. The replies were tabulated so as to show a ranking of the advantages gained, from the students' viewpoint. First place was taken by the idea that the practice tests helped by calling attention to points which the student might not have noticed otherwise. Second place went to the thought that they "needed to study sooner and hence more often." They helped "in learning the essential textbook facts" was next in sequential value in the students' minds. Sixty-two of sixty-seven replies favored the continuation of the method as a procedure worth while and helpful from the viewpoint of improving learning achievement.

From the data gathered, conclusions were drawn that self-scored and unrecorded practice-tests do stimulate and increase pupil learning of the essential textbook facts to a very high degree and that such tests are helpful in developing the attitude and ability of self-dependence in the individual student. It was also given as an opinion that such methodology would enable teachers to carry heavier pupil loads without increased effort (after the tests had once been constructed) or loss of instructional efficiency because of the elimination of the necessity of teacher-grading of papers when attempting to individualize instruction by having daily written lessons.

The method is recommended as a valuable adjunct when individualization of instruction and "learning to learn" are teacher objectives. It is also suggested as a means of making the transfer of responsibility of diagnosis and remedial activity from the teacher to the individual pupil, to whom it inherently belongs. Boys and girls must learn sometime to stand on their own feet educationally and otherwise.

Abstracts

General Education

Tyler, Ralph W. "Prevailing Misconceptions." *The Journal of Higher Education* 4:286–289; June, 1933.

Basing his conclusions on experiments carried on in twenty subject-matter departments at Ohio State University, the author concludes that certain psychological misconceptions prevent the better adjustment of the college curriculum. Discussion is devoted to each of the following five conclusions: (1) Many students who do satisfactory work in recalling important facts do not learn satisfactorily to apply generalizations to situations which they have not previously encountered; many fail to recognize problems in concrete situations; many fail in attempting to evaluate data or processes; (2) No adequate provisions have been made for individual differences; (3) Students' differences in learning are not primarily differences in the time required to learn; (4) Students who are best able to take ideas from the printed page are not in all respects "superior" college students; (5) All learning is not equally permanent or equally transient. —C.M.P.

Brownell, W. A., and Easley, Howard. "Types, Characteristics and Problems of Learning." *Review of Educational Research* 3:283–315; October, 1933.

This article is an attempt to review recent research studies relating to (a) general ability and learning, (b) transfer and generalization (c) special types of learning (d) the permanence of learning (e) genetic development of fundamental types of behavior (f) prediction and prognosis (g) errors (h) sex differences and (i) constitution of ability. The large number of studies mentioned has left too little space for critical evaluation. An excellent bibliography is appended. —C.J.P.

Koos, Leonard V. "Trends in Secondary-School Programs of Studies." *The School Review* 41:497–507; September, 1933.

Evidence of a relatively rapid growth in science offerings in secondary-school programs is not found in this summary of certain investigations relating to programs of studies in the secondary school. The tendency for non-academic subjects to gain at the expense of academic subjects is pointed out. Fields experiencing least expansion in the senior high school include science and two other academic subjects. The movement toward "general courses at the junior high-school level goes forward. The author criticizes the trends which reveal that science has shown too little disposition to swell in the offerings and in the proportions of pupils studying the subject. He suggests the huge task ahead of those interested in science instruction if they would work out a curriculum that will recommend itself to pupils and administrators. —C.J.P.

Briggs, Thomas H. "The Changing World and the Curriculum." *Teachers College Record* 35:33–35; October, 1933.

Changes in society, changes in communication and transportation, changes in industry and business, changes in wealth, changes in opportunities for leisure, changes in democracy and politics, changes in the family, changes in health conditions and provisions, changes in science, changes in ethics and religion, and changes in the secondary schools—all demand a change in the secondary school itself. —C.M.P.

Loomis, Arthur K. "The New Curriculum of the University High School of the University of Chicago." *The School Review* 41:508–518; September, 1933.

The principal of the University High School describes the revised curriculum that

has been developed in the school and that places the subjects into three integrations: (a) social sciences, humanities and language, (b) science and mathematics, and (c) fine and practical arts. A complete program of studies for the five years is outlined. The plan which places the last two years of the high-school work under the jurisdiction of the college faculty is of especial interest. —C.J.P.

WIGGINS, D. M. and SPAULDING, FRANCIS T. "When Are High Schools Too Small?" *The School Review* 41:585–594; October, 1933.

An answer to the question is attempted by a presentation of data indicating practices in respect to teacher assignments within 495 four-year high schools in Texas, in which enrolments ranged between 10 and 150 and the number of teachers from 3 to 14 to a school. It is concluded "that four-year high schools employing eight or more teachers are large enough to afford reasonably satisfactory conditions for teaching." —C.J.P.

BUSWELL, G. T. "Methods of Teaching." *Review of Educational Research* 3:316–337; October, 1933.

This chapter is one of three in the issue of the *Review* devoted to a résumé of research studies in the fields of Psychology of Learning, General Methods of Teaching and Supervision. The literature is reviewed to January 1, 1933. A brief section on Natural Science is included. A general bibliography accompanies the article. —C.J.P.

BRIGGS, THOMAS H. "Pioneers, O Pioneers." *Junior-Senior High-School Clearing House* 7:390–396; March, 1933.

In his forceful and challenging manner, the author draws a parallel between the pioneer of our physical America and the characteristics of the pioneer who is or who is to be in the educational field. The challenge on the new frontier "involves more than pedagogical improvements of traditional classics. It means creating a new civilization suited to the new frontier and intelligently using the schools as the most potent means of progress." —C.J.P.

GUILFORD, CHARLES C. "Why We Hate School." *School and Society* 38:284–288; August 26, 1933.

Statements from 112 senior high school pupils telling why they disliked school are summarized in this article. Home work in huge quantities, rigid requirements in lesson-getting, the impracticality of much school work, and lack of understanding the pupil on the part of the teacher are among the most important reasons given. —A.W.H.

WILLIAMS, J. HAROLD. "Attitudes of College Students Toward Motion Pictures." *School and Society* 38:222–224; August 12, 1933.

This article gives some data from the use of Thurstone's scale for rating attitudes toward the movies. The score is determined by the reactions of persons to statements concerning the movies. A large percentage of responses were in accordance with favorable statements about the movies and with items indicating a neutral attitude. Likewise a large fraction disagreed with items indicating an unfavorable attitude. —A.W.H.

KELLY, FRED J. "Higher Education Meeting the Depression." *Junior College Journal* 3:420–425; May, 1933.

The discussion deals first with a general analysis of various factors involved in the depression; then it considers the efforts of the higher institutions to adjust their programs and activities to these factors. The author summarizes his conclusion thus: "The colleges in order to play their part better are doing increasingly three things: they are coöperating where they were formerly competing; they are substituting for credits, other more abiding motives which establish genuine interest in study; and they are recognizing the obligation of the college—particularly the junior college—for social and civic education of the great majority of our people, especially adults." —F.D.C.

EELLS, WALTER CROSBY. "Adjustments in the Junior College Curriculum." *Junior College Journal* 3:401–410; May, 1933.

This extensive article considers various phases of adjustment of the junior-college

curricula. It discusses at considerable length the portions relating to the junior colleges in the Report of the Carnegie Foundation Commission on *State Higher Education in California*. The article closes with the proposal of eight important problems intended to serve as the basis for future discussion.
—F.D.C.

Brownell, V. A., Easley, Howard and Buswell, G. T. "General Conditions Affecting Teaching and Learning." *Review of Educational Research* 3:338–348; October, 1933.

The authors present a résumé of the investigations relating to the general conditions which "have a great deal to do with teaching and learning." Such conditions include motivation, class size, discipline, instructional materials, and others. A few references are made to studies in the field of science education. —C.J.P.

Melone, Gerald H. V. "Can Junior-High-School Learning Experiences be Unified." *Junior-Senior High-School Clearing House* 7:404–409; March, 1933.

The experiment summarized here has been carried on at the John Burroughs School, St. Louis. Following a brief statement of the guiding principles of educational philosophy and educational psychology upon which the unified curriculum is premised, there are presented the problems encountered and a general outline of the units and teaching topics devised during two years of experimentation. Science finds a significant place in the outline. The administration of the unified program is also described. —C.J.P.

Reavis, William C. "Guidance Programs in Secondary Schools." *Junior-Senior High-School Clearing House* 7:19–27; September, 1933.

Some of the findings and suggestions gained by the writer as a member of the staff of the National Survey of Secondary Education are reported in this article. The need for guidance, the extent of guidance, the guidance functionaries and activities, and the types of guidance programs are presented. It is proposed that a guidance program may be developed as an integral part of the educational program. —C.J.P.

Woellner, Robert C. "College-Freshman Vocational Selections." *Junior-Senior High-School Clearing House* 7:33–39; September, 1933.

The vocational selections of 1,365 freshmen entering the University of Chicago in 1931 and 1932 are presented and analyzed from the points of view of (a) the extent of vocational decision, (b) the sources of vocational information, (c) the distribution of the vocations, and (d) the relation of intelligence to the making of vocational decisions, and the fields of vocational choice. It is concluded that more vocational counselling in high schools and colleges is needed, that about half the students studied had chosen the crowded professions, and that quantitative studies of this nature cannot fully evaluate guidance or its results.
—C.J.P.

Science in Education

Caldwell, Otis W. and Lundeen, Gerhard E. "Changing Unfounded Beliefs—A Unit in Biology." *School Science and Mathematics* 33:394–413; April, 1933.

This article reports a further phase or unit of the elaborate and valuable study of unfounded beliefs, various parts of which have been previously reported in a monograph and in several of the educational journals. This unit was "designed to measure the effects of specific instruction regarding certain unfounded beliefs that are associated with the subject of heredity." The controlled investigation involved 231 pupils who were studying biology in two schools under eight teachers. The experimenters state among other conclusions that the unfounded beliefs considered were wide spread and that "the knowledge foundations for desirable attitudes concerning certain facts may be developed by remedial instruction." —F.D.C.

Webb, Hanor A. "The High School Library for 1932-1933." *Peabody Journal of Education* 11:1–10; July, 1933.

To those familiar with Professor Webb's previous summaries of books suitable for the high school library this is merely a reminder that the new issue was printed this July and that reprints are available from the author at Nashville, Tennessee, at the nominal sum of ten cents.

To those teachers who have not yet become acquainted with this valuable service it is suggested that it will be decidedly profitable and time saving to look up the original or to purchase the reprint at once.

Books are classified into topical groups according to the uses which they may have for high school pupils. A brief annotation of content is given for each title. For the teacher's convenience, books are classified into price groups depending upon the total funds available for the purchase of books. If a book is put into the ten-dollar list, Dr. Webb recommends the purchase if only ten dollars are available this year for the purchase of books for the library. If a book is in the $100.00 class it is recommended that the book be purchased if $100.00 are available, but that possibly it is not a wise purchase if smaller amounts are available. The books reviewed are those published during the past school year.

Previous lists back to 1924 are available with the exception of the list for 1929-1930.

—R.K.W.

Noll, Victor H. "The Habit of Scientific Thinking'" *Teacher's College Record* 35: 1–9; October, 1933.

Unscientific thinking has caused and tolerated present social and economic conditions. Taking as a thesis the importance of attitudes as determiners of behavior, the author discusses the following points: (1) The scientific attitude is one of the most desirable for individuals to acquire; (2) The scientific attitude, like other attitudes, is based upon habits of thinking which can be defined.

Six fundamental habits of thinking are described as characteristics of the scientific attitude: (1) habit of accuracy in all operations, including calculation, observation and report; (2) habit of intellectual honesty; (3) habit of open-mindedness; (4) habit of suspended judgment; (5) habit of looking for true cause and effect relationships; and (6) habit of criticism, including self-critisism.

—C.M.P.

Hufferd, Ralph W. "A Science Survey" *School and Society* 38:276–279; August 26, 1933.

Those interested in science survey courses will want to hear what the author of this article thinks are its desirable characteristics. The general plan outlined is designed to meet the science requirements in a liberal arts college.

—A.W.H.

Partridge, W. A. and Harap, Henry. "Science for the Consumer." *School Science and Mathematics* 33:266–274; March, 1933.

An analysis is made of the scientific terms occurring in the publications of Consumers' Research, Incorporated. The investigators conclude that "the main topics of the several sciences occur in the consumer bulletins studied." They urge the desirability of the layman's understanding of the meanings of the terms which the analysis revealed and suggest the need for further similar studies of "consumer" science in magazines, catalogues of mail order houses, newspaper advertisements, and government publications. The article closes with a table summarizing the occurrence of scientific terms in the bulletins analyzed, and with a list of 349 of the terms discovered together with the commodities to which the various terms relate.

—F.D.C.

Kefauver, Grayson N. and Mackenzie, Gordon N. "The Value of Secondary School Subjects in Preparing for Engineering." *California Quarterly of Secondary Education* 8:257–367; April, 1933.

The authors present first a brief review of related literature. They then report a preliminary study which consisted of an analysis of the entrance requirements of schools of engineering. The principal study consisted of an analysis of the responses to a questionnaire submitted to 50 deans of engineering schools in all parts of the country, asking their opinions concerning "(1) the extent of contribution of each of the subjects in preparation for engineering, and (2) the desirability of studying them in high school or college or both." The report presents several extensive graphs of findings

and closes with a list of nine "implications for guidance." —F.D.C.

BERRY, WILLIAM J. "Some Opinions Relative to the Content and Grouping of Geography." *The Journal of Geography* 32:236–242; September, 1933.

This is a résumé of a study made to determine the opinions of college teachers of geography as to whether geography should be included among the social sciences or among the natural sciences. The majority of opinions would have geography grouped with the sciences. Among those favoring the science grouping are the following: Whittlesey, Miller, Dodge, Jefferson, Blanchard and Simpson. Among those favoring the inclusion of geography with the social sciences are: Reeder, Finch and Zierer. Another group believes geography belongs to both the social sciences and the natural sciences. Bowman, Huntington, Fenneman and Whitbeck are included among the last named group. Quoted opinions of each of the above named geographers are included.

—C.M.P.

Science

LINDSAY, R. B., "Causality in the Physical World." *Scientific Monthly* 37:330–337; October, 1933.

The author discusses the recent controversies that have been agitating some scientists as to the true place of causality in the physical world. Some scientists have seemingly become convinced that the watchword of nature is no longer "cause" but "chance," not merely the "chance" exploited by life insurance companies, but also the kind of "chance" that is displayed in the speculations of the stock market. This latter belief has been especially predominant among those who have been peering into the atomic world. The author maintains that there is such a thing as the principle of causality in physics and that it has played an important role in the building of the physical world. —C.M.P.

ZELENY, JOHN. "The Attack on the Atom" *Scientific Monthly* 37:338–343; October, 1933.

This is a résumé of the investigations that have been made relative to the structure of the atom. First came the discovery of the electron, which was soon followed by the discovery of the proton. Recent attempts at the disruption of the atom have revealed the neutron and the positron. These latter discoveries have served as a stimulus to an intensive attack on the structure of the atom. —C.M.P.

HOLMES, S. J. "Are Genes the Product of Crossing-Over?" *Science* 78:309-311; October 6, 1933.

Following certain speculations concerning the molecular or multi-molecular composition of genes, the author briefly presents the supposition that genes may not be primitive organic entities but rather the product of a long series of evolutionary changes in chromosomes, taking place through the crossing-over of the chromosomes in the reproductive process.

—C.J.P.

HOPKINS, SIR FREDERICK GOWLAND. "Some Chemical Aspects of Life." *Science* 78: 219-231; September 15, 1933.

The presidential address delivered to the British Association for the Advancement of Science contrasts the old and the new biochemistry and presents an overview of certain scientific knowledges concerning the molecular dynamics in living cells and tissues. The address closes with a consideration of the place and function of science in modern civilization. —C.J.P.

BURCHARD, ERNEST F. "The Sources of Our Iron Ores." *Journal of Chemical Education* 10:195-204; 288-296; April, May, 1933.

The first paper discusses the relations between the iron of the interior and the crust of the earth, the common iron minerals and ores and their geographic and geologic distribution in the northeastern and southeastern sections of the United States. The second paper especially stresses the iron ore deposits of the Lake Superior states. Lesser attention is given to the western iron ores. Statistics of production of iron ore and esti-

mates of reserves of present grade are included. Both articles are illustrated. —C.M.P.

HAUBEN, SAUL S. "The Derivations of the Names of the Elements." *Journal of Chemical Education* 10:227–234; April, 1933.

The article indicates the derivation of the name of each of the 92 elements which are listed alphabetically. In most cases both the date of discovery and the discoverer's name are given. —C.M.P.

ANONYMOUS. "Beyond Einstein." *Science News Letter* 24:250–252; October 14, 1933.

The Bohr atom, the electron, the proton, the neutron, "the quantum wave mechanics," the principle of indeterminency, cosmic rays, and the relation between mass and energy are discussed as a part of the "new deal" in physics. —C.M.P.

PECK, A. S. "Sweet Beets." *Scientific American* 148:280–282; May, 1933.

This illustrated article presents the economic aspects of the sugar beet industry and briefly describes how the sugar is extracted. Producing approximately 1,308,000 tons of beet sugar in 1932, the United States took first rank away from Germany as the leading producer of beet sugar.—C.M.P.

ANONYMOUS. "Deutons Creating Neutrons Promise to Smash Atoms." *Science News Letter* 24:228; October 7, 1933.

Two particles recently discovered by science, the neutron and the deutron, promise to play an important part in atomic disintegration. Deuton is the name given to the nucleus of the hydrogen isotope of mass two. It is especially effective in producing neutrons which are in turn decidedly more effective than radium in disintegrating atoms. —C.M.P.

WEEKS, MARY ELVIRA. "The Discovery of the Elements: Chronology." *Journal of Chemical Education* 10:223–227; April 1933.

This is a concise chronology of important dates in the discovery of the elements. —C.M.P.

GRAHAM, C. D. "Air Conditioning." *Scientific American* 149:62–64; August, 1933.

This illustrated article explains what is meant by "air conditioning" and describes the methods of carrying out the process. Comparisons are made with processes of heating buildings. —C.M.P.

MARTIN, ROBERT E. "Nature Invented Them First." *Popular Science Monthly* 123:14–15; 104; October, 1933.

Man's ingenuity at building, fighting, or in capturing food is matched by the instinctive skill of plants and animals according to the author. Illustrations are included. —C.M.P.

WETMORE, ALEXANDER and BROOKS, MAJOR ALLAN. "The Eagle, King of Birds, and His Kin." *The National Geographic Magazine.* 64:43–95; July, 1933.

This is the fifth of a series of articles descriptive of all important families of birds of North America. The article includes forty-eight portraits in color from life by Major Allen Brooks. —C.M.P.

PASSMORE, LEE. "California Trapdoor Spider Performs Engineering Marvels." *The National Geographic Magazine.* 64:195–211; August, 1933.

The very interesting but comparatively little known trapdoor spiders of California are described in this article. There are twenty-three illustrations. —C.M.P.

EWING, HENRY E. "Afield With the Spiders." *The National Geographic Magazine* 64:163–194; August, 1933.

The author, entomologist of the United States Department of Agriculture, describes the better known spiders of the United States. The article includes twenty-six illustrations with sixty-four additional portraits in color from life by Hashime Murayama. —C.M.P.

Science in Senior High School

FRANK, J. O. "Contract Plan in High-School Chemistry." *Journal of Chemical Education* 10:556–559; September, 1933.

The theory upon which the contract plan is based, the functions of the teacher using the plan, and some of the desirable outcomes that should result from completion of a contract are explained by the author. An illustrative unit on "Aluminum" is included. The unit has the following divisions: (1) The exploration; (2) The presentation or stimulation; (3) Preliminary survey of the contract; (4) Investigation, organization, assimilation, and application; (5) Preliminary testing of accomplishment; (6) Completion of the contract; (7) Final test of results accomplished and award of honors. The contract is based on a three-level accomplishment basis. References and objectives for the unit are included.

—C.M.P.

TYLER, R. W. 'Tests in Biology." *School Science and Mathematics* 33:590-595; June, 1933.

The article first discusses objectives of testing, then reports an attempt to construct tests to evaluate the pupil's ability to apply biological principles in situations new to him, and to interpret biological experiments from the descriptions of such experiments, and to measure the pupil's ability to use a microscope in attacking a new problem. The article includes test items of the first two of these types of tests.

—F.D.C.

GLASOE, PAUL MAURICE. "Residue High-School Knowledge Utilizable in College Chemistry." *Journal of Chemical Education* 10:571–574; September, 1933.

A résumé of a study conducted by the author in his classes in St. Olaf College. The experiment was conducted with two sections numbering about eighty students each. Each group, for comparative purposes, was tested as to native ability by the Minnesota College aptitude test. The scholastic achievement of each student involved was measured by the grade-point ratio. Twelve tests were given during the experiment, with a final test consisting of one hundred eighty-six questions. Both the series of performance tests and the final examination gave results that point to a distinct residue of knowledge carried over from high-school to first year college chemistry.—C.M.P.

BLONDELL, CARLETON. "A Selected and Annotated Bibliography of Secondary Biology." *School Science and Mathematics* 33:309–319; March, 1933.

The author divides his extensive bibliography into the following heads: References to the Literature; The Pupils; The Social Needs; The General Units; The Specific Content; The Teaching Procedure.

—F.D.C.

MACK, PAULINE BEERY. "Our Universe." *The Science Leaflet* 7:1–30; September 14, 1933.

This number of *The Science Leaflet* is devoted to a description of some of the science exhibits at the Century of Progress Fair in Chicago. Illustrations are included (Abstractor's note: Every science teacher should have a copy of this issue of *The Science Leaflet*. It will serve as an interesting memento for those who were fortunate enough to see the marvellous exhibits. For others, not so fortunate, it will have to serve as a vicarious experience! With this number, *The Chemistry Leaflet* becomes *The Science Leaflet* and will have sections devoted to biology, physics and the other sciences as well as chemistry.) —C.M.P.

New publications

CLEMENSEN, JESSIE WILLIAMS. *Study Outlines in Physics*. New York: Bureau of Publications, Teachers College, Columbia University, 1933. 154 p. $1.75.

This is an account of some experiments carried on in nine high schools in Los Angeles, California, utilizing some specially devised study outlines for high school physics. Part I states the problem and discusses aims and objectives in physics together with the psychology and technique of study outline construction. Part II is an account of the evaluation of the outcomes of the experiments. Objective tests, essay tests, and questionnaires were used in these evaluations. All three give evidence to show that classes using the study outlines were superior to those not using them when taught by the same teachers; and that classes taught by other teachers having no knowledge of the outlines were inferior.

In general the statistical treatment is adequate. The curriculum implications for the course in high-school physics are important although the author contends that the study is not a curriculum study. The chapter on aims and objectives brings out these implications. One may question whether the data make outlining itself the primary factor contributing to achievement or whether a more plausible conclusion is the specificity of objectives which it clarifies. Perhaps the same or similar results might be brought about by some other means of clarifying objectives equally potent.

—A.W.H.

CALDWELL, OTIS W., and LUNDEEN, GERHARD, E. *An Experimental Study of Superstitions and Other Unfounded Beliefs*. New York: Bureau of Publications, Teachers College, Columbia University, 1932 138 p. $1.25.

For many years science teachers have realized that superstitions and other unfounded beliefs were still deterrent factors in the progress and elevation of the human race. There have been other studies of superstitions and local efforts to replace them with real science facts. Few teachers, however, have had material available so that they could do very effective teaching to correct the misinformation of their students.

This bulletin gives excellent concrete assistance to the science teacher. It appears that the majority of unfounded beliefs fall into three groups. To cover these, the authors have made three units: Unit 1, Some Personal problems; Unit 2, The Earth and Other Heavenly Bodies; Unit 3, Weather Conditions. If the fallacies relating to these three units can be replaced by truth, an epoch making forward step will have been accomplished.

These units were used in experimental instruction by thirty-seven teachers under the direction of the authors. Tests given before and after the instruction gave evidence that the instruction had been effective in changing the attitude of pupils towards many unfounded beliefs.

This is a bulletin that all general science teachers should study, and apply in their own science teaching. —W.G.W.

HURD, A. W. *Coöperative Experimentation in Materials and Methods in Secondary School Physics*. New York: Bureau of Publications, Teachers College, Columbia University, 1933. 60 p. $0.60.

The coöperative experiment carried on

by a number of schools under the direction of Dr. Hurd for the school year 1931-1932 is outlined in this report. The earlier experimentation upon which this work is based was carried on under the auspices of the North Central Association and reports of the earlier experiments may be found in the issues of the *North Central Association Quarterly*. The present series of experiments is carried on through the Institute of School Experimentation of Teachers College.

The experiment for the year 1931-1932 was based upon detailed plans for the teaching of one unit of the high-school physics course, the unit on electric lighting systems. The plan includes the following features: a definitely outlined unit plan; an outlined teaching technique; a text covering the subject matter of the unit; work sheets for pupils; a list of individual projects; preliminary and final tests upon the minimum essentials of subject matter included in the unit.

The conclusions concerning results are based upon the gains of pupils as shown by differences of scores upon the preliminary and final tests. These gains are compared with the similar gains of control groups in other schools in which the same tests were given but in which the plans of the experimenter were not used.

Some of the conclusions derived are as follows: "Concentrating attention upon securing high final scores on minimum essential tests, and making plans therefor, pays dividends in pupil achievement."

"Remedial instruction, based upon a study of pupil responses to items in a preliminary test, is a valuable plan of teaching."

"Experimental schools as a group far surpassed control schools . . . The unit content and experimental plan . . . resulted in increased pupil achievement."

"Provision for specialized activities or projects is a workable method of caring for individual differences. . . ."

"Evidence from these experiments favors classes in physics of fewer than 20 pupils, if high achievement is a specific objective."

The author's experimental plan does not utilize a great volume of statistical technique as have the majority of recent educational experiments. There are factors involved that are difficult to control under the experimental conditions. The author is aware of these difficulties. The experimental method used has the decided merit of testing under the field conditions under which the final results must be used. It is time for more experimenters to be willing to forego some of the niceties of the laboratory in favor of the possibility of operation under existing school conditions.

For the teacher of physics, chapter one of this monograph will be found extremely valuable. Here Hurd has summarized the results of his earlier experimentation at the University of Minnesota and with the North Central Association. Packed within less than thirty concise statements are tentative answers to many of the difficulties which present themselves to high-school physics teachers. —R.K.W.

OBOURN, ELLSWORTH S. and HEISS, ELLWOOD D. *Science Problems of Modern Life*. St. Louis: Webster Publishing Company, 1933. Book I, 201 p. $0.42; Book II, 184 p. $0.42

These books are in the form of workbooks. Air, weather, water, light, heat, and mechanics are taken up in Book I; and heavenly bodies, soil, life, electricity, communication, and transportation in Book II. There is a brief introduction to each unit. Blank spaces are left for pupils to make notes on experiments and to answer questions. The books are easily adapted to any method of teaching and may be used with any text. Unlike most workbooks, a good deal of textual material is contained in the workbook, so that in case of necessity, a course could be given with no other text. However, each topic treated, is accompanied by helpful references to most of the commonly used general science texts. Each topic is followed by a completion test under the title "Testing your Mastery of this Topic" which is in the nature of an instructional test, and indicates whether the pupil has mastered the topic or not. Supplementary work is suggested so that the pupil of superior ability may not lack for something to do. These attractive books show careful and painstaking work on the part of the authors. They are illustrated with half tones and line cuts. The line cuts are particularly good. While adapted to any method, these books encourage the use of the problem-solving method, and set a high standard of accomplishment. It

is suggested that the books may be used in either the eighth or ninth grades.

—W.G.W.

Pieper, Charles John and Beauchamp Wilbur Lee. *Everyday Problems in Science: Revised Edition.* Chicago: Scott, Foresman and Company, 1933. 734 p. $1.60.

This is a revision of the authors' *Everday Problems in General Science*, first published in 1925. This earlier book was probably the first science book on the junior-senior-high-school level utilizing the "unit-problem plan" of organization and of method. In the subsequent years *Everday Problems in Science* exerted a tremendous influence in science textbook writing not only in the field of general science, but in the secondary field as well. Practically all recent books in general science, and to a large extent those in biology, have used this same general plan. As a rule, better textbooks mean better classroom teaching. The improvement in textbook writing has probably been the most important factor in the improvement of the classroom teaching of science.

In this revision "based on seven years of classroom use and the criticisms of thousands of teachers of science," the authors have brought the subject-matter up to date, and have introduced several new problems, new illustrations and new questions. The study suggestions for pupils and the suggested activities for additional study, scattered throughout the units, are among the features of the revised edition. The references and guides for additional study, which are unusually complete, have been brought up to date and are greatly improved in usefulness. A Teachers Guidebook and a series of tests covering each of the seventeen units will be prepared to accompany the textbook.

—C.M.P.

Skilling, William T. *Tours Through the World of Science.* New York: McGraw-Hill Book Company, 1933. 758 p. $1.70.

The title of this general science textbook is challenging. That is a good starter. Each section (usually called chapter, sometimes called unit) is a "tour." Each tour is introduced by a few paragraphs telling "where the path will lead." Follows "preparation for the trip" which includes several questions or topics upon which the pupil is asked to write what he now knows. Then a signpost with a different caption for each "tour" points to the beginning of the text proper which is intended to represent the "tour." The text is quite like that found in other similar general science textbooks.

There are nineteen "tours" in the book. The first six are somewhat like the content of books on physical geography: The Earth, The Sea, The Air and the Weather, Water and its Uses, Rocks and Minerals, Astronomy. "Tour 7" is on the Chemistry of Common Things. The next seven "tours" cover much of the present subject matter of physics including content on machinery, engines, everyday electricity, communication, sound, light, heat. The last five "tours" cover biological content about plant life, animals, low forms of life, the human body and its care, foods. The information is up-to-date and seems to be put in interesting style for junior-high-school pupils. A try-out with school children may show how well they react to it.

—A.W.H.

Blaisdell, J. Glenn. *Exercise Book in High School Biology.* Yonkers-on-Hudson: World Book Company, 1933. 167 p. $0.72.

This is a workbook for high school biology to accompany *High School Biology* by Blaisdell and Presson. It may also be adapted to use with other biology texts. There are fourteen major units and 82 exercises. Some of the exercises are of the usual workbook type, others are typical laboratory exercises.

Exercises are not built upon any one uniform plan. For some demonstrations and laboratory exercises the object is given, for others it is not. Lists of required materials are to be found at the beginning of each exercise. For more difficult drawings, outline sketches are provided which are to be filled in by the pupil.

Teaching aids include the following: a complete list of apparatus for the course; a suggested seasonal arrangement of exercises and projects; one field trip record; a flower record; five review sections; a list of 80 projects grouped into fall and spring projects; and a list of museum materials,

charts, pamphlets, etc. Review sections include such materials as a memory drill upon biology terms review questions; incomplete stories; recent examination questions; a test on plant biology; a test on animal biology; a test on human biology; a recent high school examination in biology; and recent college entrance examinations in biology. This material is classified under plant, animal and human biology. It is the opinion of this reviewer that much of this review material could be incorporated as workbook material with the original units of the course.

Mechanically the book is unbound. Leaves are punched for rings but rings are not provided.

There is a dearth of useful workbooks in the field of high-school biology. This book is a welcome addition to this too little worked field. Teachers of high-school biology will wish to examine it with interest.

—R.K.W.

GREEN, GEORGE REX. *Trees of North America*. Volume 1—The Conifers. Ann Arbor, Michigan: Edwards Brothers, Inc., 1933. 186 p. $2.00.

This book is the first of a two volume series on the trees of North America. It will be welcomed by elementary science, biology and botany teachers, and others who have felt the need of a tree book that gives more than botanical characters. Under each species are given the scientific name and its synonyms, the common names and the botanical characters. Paragraphs are devoted to the leaves, the flowers, the fruits, the buds and twigs, the wood, the form and size, the root-system, the distribution, local occurrence, the soil, moisture and light requirements, growth and age, reproduction, and the value for shade and ornamental purposes. —C.M.P.

HURD, ARCHER WILLIS. *An Experiment in the Use of a Teaching Unit in Science.* New York: the Author, Institute of School Experimentation, Teachers College, Columbia University, 1933. 50 p. $0.60.

During the past several years the author has conducted a series of experiments attacking the problem of content and method in high-school physics. This monograph reports the results obtained during the school year 1932–1933 on the teaching unit, "Electricity in Communication." The experimental teaching unit was planned to emphasize: (1) What the author defines as "minimum essentials" and (2) Supplementary extra-class work. Preliminary and final unit tests of the short-answer type each containing 105 items, served as means of measuring achievement. Twenty-five schools cooperated in the study. Results seem to indicate a positive justification for this type of unit treatment in physics teaching rather than the conventional divisions now in vogue. Experimental studies such as this are of inestimable value in placing the teaching of science on a more desirable and justifiable basis. The technique described and used in this unit are adaptable to any science class whether it be on the elementary, secondary or college level.

—C.M.P.

CLARK, W. M. *Manual of Mechanical Movements*. The Author, 416 Clark Street, South Orange, New Jersey. 1933. 122 p. $1.00.

One of the most interesting and educational exhibits at the Century of Progress Fair in Chicago was called "Mechanical Wonderland." It consisted of one hundred and sixty mechanical movements, devices and combinations of movements—all operating on a large display panel. Similar exhibits are found in the Science Museum in New York City and in Newark New Jersey Museum.

This *Manual of Mechanical Movements* illustrates and describes 507 mechanical movements and devices. Comparisons are made with similar devices and the especial use of the particular device is pointed out. Every boy interested in machines and in learning "how the thing" works, will be interested in this book. General science and physics classes will find the book most useful, interesting and informational.

—C.M.P.

FLINT, W. P. and METCALF, C. L. *Insects: Man's Chief Competitors*. Baltimore: The Williams and Wilkins Company, 1932. 133 p. $1.00.

In many respects this volume of A Century of Progress Series is the best of the series. Reminiscent of L. O. Howard's *The Insect Menace*, the authors portray insects as man's chief rival for the dominence of the earth. Experts of the Bureau of Entomology estimate that, on the average, there are about 25,000,000 insects over each square mile of the earth's surface, whereas the human population in the United States averages less than 50 per square mile. Insects may well overwhelm man because of this great superiority in numbers. The author's answer to the title of the first chapter "How Insects Fight Men" is the expression, "By Eating Everything." Chapter II—is entitled "How Man Fights Insects." A rather long chapter, "What Is It?" describes several orders of insects and the last six chapters single out six insects whose lives, habits and depredations are most remarkable and dangerous.

The book is written in a literary style that will appeal to high-school boys and girls, and to all non-specialists in biology. It is recommended as an excellent addition to the high-school science library, and as admirably suited for required outside reading in high-school biology. —C.M.P.

Bossard, James H. S. *Man and His World.* New York: Harper and Brothers, 1932. 755 p. $3.50.

In *Man and His World* the author surveys the physical and social sciences. It is based on the course offered in the Wharton School of Finance and Commerce of the University of Pennsylvania. The work is a joint enterprise. All the contributors to the present volume are or were formerly connected with this school. Moreover, it is worth noting that each author is a non-specialist in science. All of the material has been tried out in the classroom, each chapter being subjected to repeated experiment, criticism and suggestion. The course would seem to offer excellent possibilities for similar courses in other schools of commerce course which feel the need of a general survey in science. This attempt to integrate and to correlate the social sciences and natural sciences into a single course at the college level seems to have been fairly well accomplished. To the reviewer, there seem to be some weaknesses in the selection and organization of the natural sciences. It is our belief that the book might have been considerably improved by having as co-authors one or more individuals whose major training had been in the field of natural sciences, although such authors need not have been, necessarily, specialists in the pure sciences. —C.M.P.

Hotchkiss, William O. *The Story of A Billion Years.* Baltimore: The Williams and Wilkins Company, 1933. 137 p. $1.00.

This is a rather brief over-view of the field of geology, one of the few sciences in which America may rightfully claim superiority. Needless to say, only a few of the "high spots," are touched upon, such as the origin and the age of the earth, the record of past life upon the earth, climates of the past; the great ice-age and geologic resources. It is a book for the high-school science shelf, the elementary science teacher, and others who may be without a fundamental background of geological processes and theories. —C.M.P.

Cole, Fay-Cooper. *The Long Road from Savagery to Civilization.* Baltimore: The Williams and Wilkins Company, 1933. 100 p. $1.00.

This is a book on anthropology by a well-known anthropologist of the University of Chicago. In the book the author accounts for the racial, cultural and social organization differences that differentiate men. All that is known about man goes back only a few million years and from then until a paltry 50,000 years ago the traces left by ancient man are sketchy and sporadic. As man judges time it has been a long road from savagery to civilization but geologically speaking, man has accomplished much in a relatively brief period of time. Judged by the latter standard, man's future is bright indeed. Certainly there is no need for discouragement, even in times of depression! High school students and laymen will enjoy reading this treatise.

—C.M.P.

Foley, Arthur L. College Physics. Philadelphia: P. Blakiston's Son and Company, 1933. 759 p. $3.75.

According to the author, "the chief function of the physics teacher, or a textbook is not to impart facts, but to arouse and maintain a keen interest in the physical phenomena." In keeping with this idea, the author has included more than the usual amount of historical material, uses a conversational style, and is more inclined to be verbose than brief. An attempt has been made to insure better balanced lesson assignments by making the chapters of practically even length. A new departure has also been taken relative to problems. Problems have been arranged in similar pairs. The answer to the odd-numbered pair is included, whereas the even-numbered problems are not answered. The text has the usual content divisions and sequence.

The reviewer disagrees with the author who maintains that "photographic pictures tend to detract from the interest of the subject" and for this reason very few are included. Pertinent pictures, well selected add to the attractiveness and teachability of any science subject. Also, the reviewer regrets the omission of lists of supplementary reading material. Such lists are especially desirable in a text of this kind which seems to be intended for general and cultural classes in physics rather than for engineering students. —C.M.P.

Sheard, Charles. *Life-Giving Light.* Baltimore: The Williams and Wilkins Company, 1933. 174 p. $1.00.

This book on biophysics is a concise authentic treatise on light—the important link between the organic world and the inorganic world. The author is Professor and Director of Biophysical Research of the Mayo Foundation, University of Minnesota and The Mayo Clinic. In this book, he records the progress man has made in discovering the secrets of light, especially as this progress relates to solving the mystery of mysteries—Life. The reviewer recommends this book as an excellent addition to the science shelf of the high-school library. Both biology and physics students will find it excellent for collateral reading. —C.M.P.

Hale, William J. *Chemistry Triumphant.* Baltimore: The Williams and Wilkins Company, 1932. 151 p. $1.00.

This rather brief essay on the relation of chemistry to modern civilization has been admirably done. It is recommended as an excellent addition to the library science shelf. Although a background of chemical information is essential to a complete understanding of the entire essay, those without this background will find it profitable and enjoyable reading. Chapters are devoted to the place of chemistry in industry, mining, agriculture and transportation.

Dr. Hale believes that civilization is on a chemical threshold and that past accomplishments are insignificant in comparison to those which are to follow. In an interesting chapter on Chemeconomics the author elucidates the following principles of chemeconomics: (1) All handiwork of man disintegrates with time and, except for art or monumental structures, its valuation decreases in direct proportion to this time factor; (2) The best that man can do today will be antiquated on the morrow; (3) In an advancing civilization, the prices of basic commodities must ever seek lower and lower levels in order that a greater and greater spread between this price and selling price of finished products may make possible ever increasing expenditures for improvements; (4) With increasing income and education there is no upper limit to the capacity of man's wants; and (5) All industry is basically chemical and hence industrial investments warrant constant chemico-physico-biological scrutiny. —C.M.P.

Ridgley, Douglas C. and Koeppe, Clarence E. *Fundamentals of Climate.* Bloomington, Illinois: McKnight and McKnight, 1932. 63 p. $0.40.

The authors give a brief, non-technical, authoritative summary of the fundamentals of climate. Approximately one-half of the book is devoted to a study of meteorology as a basis for the discussions of climate in the last half of the book. A number of maps and charts are included. It is an excellent reference for geography, elementary science and general science teachers. —C.M.P.

Mantell, C. L. *Sparks from the Electrode.* Baltimore: The Williams and Wilkins Company, 1933. 127 p. $1.00.

A description of the growth of the electrochemical industries with the advent of cheap power is given in this volume. Electrolytic refining of metals, electroplating and the electrolytic prevention of corrosion are described. There is an illustrated chart showing the development of electrochemistry. Two tables interestingly portray the chief products, the total production, total value and the power consumption of the electric furnace and the electrolytic cell.

—C.M.P.

Squier, George O. *Telling the World.* Baltimore: The Williams and Wilkins Company, 1933. 163 p. $1.00.

This is a treatise on the development of electrical communication. An initial chapter is devoted to describing the discovery and development of fundamental principles. The following chapters discuss the telegraph, the telephone, radio and the signal corps. Readers not mathematically inclined may well ignore the numerous formulæ included. While not quite as readable as most Century of Progress Series, science books, *Telling the World* does present an excellent account of the development of modern communication. —C.M.P.

Wheat, Frank Merrill and Fitzpatrick, Elizabeth T. *Everyday Problems in Health.* New York: American Book Company, 1933. 440 p. $1.20.

The authors have presented this volume as "a basic text for the scientific teaching of pupils in junior- or senior-high schools." In the point of view of the reviwer, it is better adapted to the maturity of junior-high pupils than to that of senior-high-school pupils. The content is concerned with problems of home, personal, and community hygiene.

The authors have succeeded unusually well in getting away from the older type of structural physiology and anatomy familiar in the older health books. The book has decided merit in its direct attack upon the health problems which immediately concern the layman.

There are five major units and 28 chapter problems. The major divisions are: health and the high-school pupil; eat and live healthfully; putting food to work; control of the healthy body; and maintaining a healthful home. Sample chapter problems are: exercising for health; how to resist disease; cleanliness and health; foods or fads; getting rid of wastes; glands of control; how to improve your personality; selecting a home; dressing for health.

Teaching devices include unit previews and exercises and questions at the end of each chapter problem. The exercises are better done than most of those found in health and hygiene books. The experimental approach is well maintained in the exercises and they are such that most pupils can carry them out without elaborate apparatus. —R.K.W.

Bragg, Sir William. *The Universe of Light.* New York: The Macmillan Company, 1933. 283 p. $3.50.

Nine chapters on "Light" written for the educated layman in understandable language and comprehensive style are included in this volume. The chapter headings give an idea of the content: The Nature of Light, The Eye and Vision, Colour, The Origins of Colour, The Colours of the Sky, The Polarization of Light, Light From the Sun and Stars, The Röntgen Rays, and The Wave and the Corpuscle. Twenty-six plates and 110 separate figures illustrate the verbal discussions given. A major objective in the mind of the author is to show how the wave and corpuscular theories are being reconciled.

The book supplements the usual textbook by giving more natural and conversational explanations. The author is especially happy in his use of analogies with more familiar phenomena to explain the less understood phenomena in the realm of light. Two sentences from his last chapter bring the reader to some comprehension of the progress which has taken place in human thought due to recent research in physics: "Light, visible and invisible, X-rays, the emissions of radioactive substances, electrons, matter itself, are now seen to have common properties and to be united in some manner which we do not yet fully understand.—We may rightly speak of light as constituting the universe when we give the word the full meaning which this prospect reveals to us." —A.W.H.

CHEESMAN, EVELYN. *The Growth of Living Things.* New York: Robert M. McBride and Company, 1932. 192 p. $2.00.

The ways and means by which sex education may be introduced naturally into the lives of boys and girls has always been a moot question. Just how, when, and how far one may or should go in discussion of sex questions has long vexed those who believe much could be accomplished in directing the thought life of boys and girls along these lines, if only the proper approach could be tactfully made. *The Growth of Living Things* does this important work with delicacy and accuracy. Written with a simplicity and a language that a child of fourteen can understand, the volume will serve excellently as a supplementary reader for general science and biology students, and also in the field of elementary science. Lay readers, too, will find the volume interesting reading.

Beginning with the smallest unicellular creatures, the thread of life is carefully traced until it reaches its highest development in man. Special emphasis is given throughout the volume in showing the need of differentiation of sex, and the need for fatherhood and motherhood in the animal and in the human kingdoms. Particularly interesting and useful is the author's conception that there is a general plan of every living creature. Two powerful forces, the urge to feed and the urge to multiply, both of which constitute the animal's love of life, carry the animal on to its highest development. Surrounding each animal are certain controls which permit the animal to develop along determined lines. These controls or guides are listed as: sense organs, food supply, competition, enemies, and climate. In later chapters, the author elaborates upon the methods through which these guides and urges operate in nature.

A suggested outline for a course of lessons is included. —C. M. P.

JENNINGS, H. S. *The Biological Basis of Human Nature.* New York: W. W. Norton and Company, 1930. 384 p. $4.00.

In *The Biological Basis of Human Nature* the author presents those aspects of modern experimental biology that have to do with the problems of human personality and society. It deals with the origin, development and nature of the traits which distinguish individuals, and which in man make up character. Much of the material is drawn from the field of genetics and experimental biology.

Jennings is the Henry Walters Professor of Zoölogy and director of the Zoölogical Laboratory in the John Hopkins University. He is noted for his experimental researches in the physiology of small organisms, and in animal biology and genetics.

The first five chapters discuss genes and chromosomes and the nature of development of individuals. Chapter six discusses the relative importance of heredity and environment. Chapters nine to twelve discuss the application of our knowledge of heredity and environment to such social problems as: biological fallacies and human affairs; what can we hope from eugenics?; the biological basis of marriage and the family; and race mixture and its consequences. Later chapters discuss environment and the future of the race, the inheritance of acquired characteristics, and diverse doctrines of evolution.

As may be gathered from the above-listed chapter headings, this book considers fundamental questions that are of great interest to many individuals. Written in simple, non-technical language, the author uses experimental studies in biology and genetics to explain the biological basis of human nature.

The book is recommended to laymen, to students of biology, and to teachers of elementary science and secondary science as an authoritative treatise on the behavior of human beings from the biological standpoint. —C. M. P.

SINGER, CHARLES. *The Story of Living Things.* New York: Harper and Brothers, 1931. 572 p. $5.00.

In this volume the author has made a survey of the historical development of biological problems. Although forming as complete a history of biology as may well be encompassed within the pages of a single volume, it is by no means a frag-

mentary study. A thread of continuity runs through the whole treatise and material extraneous to the development of the main theme has been omitted. The book serves most excellently the purposes of biographical study of the great leaders in the field of biology. In biology, as in other fields of science, each advancement and achievement is associated with the name of an individual or individuals who have made outstanding contributions to this advancement and achievement.

The author is well qualified to write such a story of living things. He was for many years a lecturer on the history of biology at Oxford University and in 1930 gave a series of lectures at the University of California.

Numerous illustrations, diagrams, charts, and cross-references add much to the usefulness of the book. Those biology teachers who desire to enliven their discussions by emphasizing the human aspects of biology will find that the book serves their purposes most adequately. Science teachers err when they neglect the historical aspects of their subject. There are few better means of teaching scientific attitudes and scientific methods than through the study of the lives of men who themselves exemplified the scientific attitude and the scientific method in investigating and solving the problems of science. —C. M. P.

Langdon-Davies, John. *Man Comes of Age.* New York: Harper and Brothers, 1932. 265 p. $3.50.

The author of this book explains what modern science is driving at. He explains why all that we are told by scientists about space, matter, time, life, and human personality seems to contradict flatly the evidence of our senses. Our common-sense universe must be abandoned if we are to accept the scientific picture of the universe.

"The common-sense world has been destroyed by science . . . space, time, matter, life, thought, personality are not what they seem to be; common-sense tells lies about all of them."

The tools of knowledge are the eye, language, and mathematics. All are necessary in order to understand the world—the world of reality which is quite different from the common-sense world. This world of reality can only be described mathematically; never pictorially through the medium of language.

Most men live in a world of make-believe. It is permitted only a few rare souls to dwell in the world of reality where things are quite different from what they appear to be to the dwellers of the world of make-believe. In his chapter on "What May I Do," the author comes to the following philosophical conclusions regarding the chief revolutions of thought which are necessary if modern scientific attitudes are to replace those at the basis of orthodox social procedure with regard to human conduct:

"(1) In the world of reality, there is neither good nor justice nor standards for right conduct. These belong exclusively to the world of make-believe, and being man-made must subserve human ends, notably the safe-guarding of human happiness;

(2) Every act is unique; no code can assist us in judging what ought to be done in a particular circumstance;

(3) Before God the thief is no more at fault than the owner of the property he has stolen. The fact that the thief gets punished is due to no higher or more ethical cause than the mere accident that criminals are less powerful and less well organized than the rest of society;

(4) Responsibility for action does not exist or cannot be discovered. The reasons a man gives for good or bad conduct are seldom or never those which really called forth his activity. The quantity of adrenalin in the blood at a given moment may be the cause of a man being a murderer or an adulterer;

(5) Morality is nothing more than the mean of the emotional wishes of the majority at any given time;

(6) Law and ethics are alike based on a fiction, a common-sense picture of the human personality which contradicts all biological and psychological knowledge of human nature;

(7) Common justice for all alike is an absurdity. Normal conduct is a fiction."

Man Comes of Age gives a philosophical view, a comprehensive view, as to how science is influencing the morals, conduct,

and happiness of man. But no one wonders if man has come of age or is he rather in his infancy? —C. M. P.

CLARKE, BEVERLY L. *Marvels of Modern Chemistry.* New York: Harper and Brothers, 1932. 374 p. $3.00.

Marvels of Modern Chemistry is a sequel to the late Ellwood Hendrick's *Everyman's Chemistry* published in 1917. *Everyman's Chemistry* represented practically the first attempt to popularize chemistry, and coming as it did during the fervor and enthusiasm of the war period, it was widely acclaimed by competent critics as a high achievement in the humanization of science. Other writers followed Hendrick, and today we have quite a number of excellent treatises on chemistry, specifically written for the layman in a non-technical language that he can read and understand.

It was the intention of Hendrick to bring his earlier book up-to-date by taking full cognizance of the mighty strides made by chemistry in the last decade. He selected Clarke as a co-author for this new book and an outline for the new book was agreed upon. The death of Dr. Hendrick intervened before the work was completed. Thus Clarke became sole author of the new work. That he has accomplished his task and maintained the high standards of achievement of the earlier work is evident upon a careful reading of the book. His treatment of the newer theories of atomic structure (the Bohr atom and the Heisenberg atom, the relation of Planck's Quantum Theory, and De Broglie's Wave Mechanics to the new atom) is an excellent piece of work for a book about chemistry written expressly for the layman.

The presentation is divided into three parts: (1) "Theoretical Chemistry," (2) "Inorganic Chemistry," and (3) "Organic Chemistry." The latest discoveries in each of these fields are presented in as much detail as is permitted in a work of this sort. Attention is paid to the place of chemistry in past and future wars, its place in modern industry, and its value to the human race.

This volume is recommended as an excellent addition to the high-school chemistry bookshelf. —C. M. P.

ILIN, M. *What Time Is It?* Chicago: J. B. Lippincott Company, 1932. p. $1.50.

This book, translated by Beatrice Kincead from the Russian edition, is a story of clocks. The author is well-known for his *New Russia's Primer* and *Black on White*. The slow struggle for the proper division of day and night and man's ingenious devices for measuring time makes this a fascinating story. What devices man has used for measuring time! Sun, stars, water, stones, roosters, oil lampe, candles, steps, sand, pendulums and springs—each has had its place as a time-measuring instrument.

This is a book for both juveniles and adults. The original Russian illustrations by N. Lapshin are included. —C. M. P.

COLLINS, A. FREDERICK. *The Metals.* New York: D. Appleton and Company, 1932. 310 p. $2.00.

This publication is intended as a reference book for chemistry students, teachers, and others seeking information about the metals, their alloys, amalgams and compounds. Although somewhat encyclopedic in nature, the simple, lucid style makes it a book far more interesting than the usual encyclopedia, or the average textbook on metals. Each metal is described as to its properties, its discoverer, and how and where it was first found. There is an interesting chapter devoted to the hypothetical metals—metals men believed to exist but later proved to be non-existent.

Chemistry students reading this book will find their chemistry more interesting and understandable. Chemistry teachers will find it a handy source of reference. —C. M. P.

Symposium. Physics of the Earth III: Meteorology. Washington, D.C.: National Research Council, 1931. 289 p. $3.50.

This is one of a series of bulletins on *The Physics of the Earth* prepared by a committee of the National Research Council. The purpose of the bulletins is "to give to the reader, presumably a scientist, but not a specialist in the subject, an idea of its present status together with a forward-looking summary of its outstanding problems." An examination of the various

Bulletins of this series affirms the accomplishment of this purpose. Each contributor is a recognized authority in his particular field. For authoritative information regarding the status of important problems in the various fields of geology the bulletins will be found to be very useful.

The following authors contributed chapters to the bulletin on meteorology as follows: Herbert H. Kimball, "Development of the Science of Meteorology"; William J. Humphreys, "The Atmosphere: Origin and Composition"; Alfred J. Henry, "Meteorological Data and Meteorological Changes"; Herbert H. Kimball, "Solar Radiation and Its Rôle"; Willis R. Gregg, L. T. Samuels, and Welby R. Stevens, "The Meteorology of the Free Atmosphere"; Hurd C. Willett, "Dynamic Meteorology"; and Richard Hanson Weightman, "Physical Basis of Weather Forecasting."

—C. M. P.

Cox, Philip W. L. and Long, Forrest E. *Principles of Secondary Education.* Boston: D. C. Heath and Company, 1932. 678 p. $2.40.

A survey and evaluation of the American high school based on the findings of psychologists, social investigators, and educational researches is presented in *Principles of Secondary Education.* The authors analyze the aims, the failures and the criticisms of the present high school and find therein more of chaff than grain. So much research needs to be done, so many changes need to be made, before the high school even begins to live up to its possibilities and functions as it should in the American democracy! Vastly different will be the high schools of tomorrow when present outmoded practices in organization in curricula in classroom procedures, and so on, have been cast aside.

The nucleus of the book is twenty-five basic principles, each succinctly and carefully stated. Each principle is discussed, explained and constructively applied. Examples of a few of these principles are:

High-school procedures, to be effective, must conform to the laws of learning.

High-school procedures, to be effective, must be adapted to the varying levels and types of intelligence and aptitudes of the potential pupil population.

Subject matter, by which is meant not only the organized "subjects" but also the less formal activity units, furnishes the raw material of experience. Appropriate subject matter, including all activity units, should be provided whereby each pupil's efforts will be challenged and wherein he may achieve reasonable success.

Principles are classified under the following four heads: Part I, "The Institution"; Part II, "The Pupil"; Part III, "The Curriculum and Student Activities"; Part IV, "Changing Conceptions of Secondary Education."

—C. M. P.

Malin, J. E. *Malin Diagnostic Test in the Mechanics of High-School Chemistry.* Bloomington (Illinois): Public School Publishing Company, 1932. $.15.

The purpose of this test is "to diagnose the difficulties of students in the mechanics of high school chemistry and its related fundamentals." There are two forms of the tests, Form A and Form B.

Each test consists of two parts. Part I contains forty items of the true-false type upon the properties of gases. Part II contains forty-one items of various type questions relating to laws, theories, the write of formulas, the naming of formulas, the writing of equations and the solving of numerical problems. Selection of items are based on three criteria: first, upon the analysis of six leading high school chemistry textbooks and manuals; second, upon student errors as found in the authors previous studies and upon the errors made by the 1960 students in the author's recent investigation; and third, upon the analysis of the College Entrance Board Examinations from 1917 to 1927 inclusive. "Every item in the text, with the exception of two, is taught in over 90 per cent of the public schools, as shown by 96 questionnaire returns from every state in the Union, except Nevada. The six leading textbooks and manuals were also determined by means of this same questionnaire."

Validity and reliability of the test seems to be satisfactory. Tentative standards are given for each form of the test.

—C. M. P.

Symposium. Nineteenth Annual Conference on Educational Measurements. Bloomington (Indiana): Indiana University Book Store, 1932. 139 p. $0.50.

Papers presented at the nineteenth conference on Educational Measurements held at Indiana University April 21, 1932, are included in this bulletin. The list of speakers, together with the title of their papers are as follows: Irvin T. Shultz, "A study of Individual Differences of Scores made in Similar Learning Tests"; Harold Littell, "Some Failures and Achievements in the Broader Aspects of Measurement: A Study in Comparative Education"; Levi M. Krueger, "A Summary of Studies in Leadership"; Paul L. Dengler, "On Elementary Education in New Austria"; Paul L. Dengler, "Some Remarks on Teacher Training in Europe"; Arthur I. Gates, "Experimental and Critical Appraisal of Certain Progressive Methods"; George C. Brandenburg, "Why College Teachers Fail"; Raleigh W. Holmstedt, "Child Accounting in Indiana"; Arthur I. Gates, "Improved Methods Suggested by Recent Research"; Arthur I. Gates, "Newer Methods and the General Objectives of Education"; A. Max Carmichael, "Primary Children's Comprehension of a Social Situation"; and Arthur I. Gates, "Recent Investigations of Instruction in Spelling."

—C. M. P.

Davis, Lillian B. "Prevention of Communicable Diseases." New York: Cleanliness Institute, 1931. 16 p.

The purpose of this unit is to develop in the pupils the attitude of personal and community responsibility for the prevention of communicable diseases by having them understand the causes and methods of transmission of these diseases. The unit has been tried out experimentally in some of the Baltimore schools, about 2200 children in 7-A Health classes and 18 teachers have studied it. Problems, exercises and references, as well as a list of basic understandings, are included in the unit. The unit is organized as a pupil's guidebook.

—C. M. P.

Pack, Charles Lathrop and Gill, Tom. *Forest Facts for School.* New York, N.Y.: The Macmillan Company, 1931. 336 p. $0.80.

Forest conservation is becoming an increasingly important economic problem. Many writers within recent years have called attention to the fact that our once abundant forests are being rapidly depleted largely because of wasteful methods of lumbering and carelessly started forest fires. With our usual American complacency we have refused to take the situation seriously and adopt and put into actual operation a practicable policy of forest conservation. The public must be educated to the importance of taking an active interest in or at least a sympathetic attitude toward problems of forest conservation. For many reasons the public schools offer the best medium for an effective program of education.

Forest Facts for Schools presents much useful information that teachers on all grade levels may use in their classwork. Biology and general science students will find the book an excellent supplementary reader or textbook. At the close of each section there are a series of test questions and exercises.

Unit one on "The Tree" discusses: Getting Acquainted with Trees; How Trees Grow; and How Trees Multiply. Unit two on "The Forest" discusses: How the Forests Help Mankind; How a Forest Becomes Established; The Forests of Long Ago; Forests of the World; and Forests of the United States. Unit three on "Forestry" discusses: How the Forester Works; Forestry and the World's Timber Supply; Forestry in the United States; Forestry in the National Forests; Forestry and the Farmer; Industrial Forestry; and Forestry and Wild Life. Unit four on "Forest Products" discusses: Lumber and Lumbering; The War Against Wood Waste; Making Paper from Wood; and Other Gifts of the Forest. Unit five on "Enemies of the Forest" discusses; Fires and Storms; and Living Enemies of the Forests.

—C. M. P.

News and announcements

To Teachers of Science

The Council of the American Association for the Advancement of Science has authorized its Committee on the Place of Science in Education to prepare a one-day program to be given in Boston, Friday, December 29, 1933. The complete program is enclosed herewith. We will be glad to mail additional copies of this program to individuals or associations who request them. This program will be printed as part of the official program of the A.A.A.S. The Committee was authorized to invite to this program science teachers and representatives of organizations of teachers of science. We wish to give wide distribution to this invitation to cooperate, and it is hoped that many teachers will be interested in attending. It is possible that those who attend will wish to take action relative to some kind of national organization of teachers of science.

We desire to have all science teachers' organizations represented by appointed delegates and by any other members who may wish to attend. Individuals who are not members of organizations of science teachers or of the A.A.A.S. are invited. Will you please extend this invitation as you may have opportunity to do so.

The luncheon at the Walker Memorial at twelve o'clock, at which Dr. John C. Merriam, President of the Carnegie Institution of Washington, is to speak on the topic "Some Reactions of Science Upon Those Who Study It," will be priced at $1.00 per person, to be paid at the time of the luncheon. Will all persons who expect to attend this luncheon advise the chairman of the committee as early as possible in order that the approximate number to be served may be reported in ample time to the Walker Memorial.

Otis W. Caldwell, Chairman
Karl T. Compton
E. R. Hedrick
Jerome Isenbarger
Burton E. Livingston
Morris Meister

TEACHERS OF SCIENCE—PROGRAM

Arranged by the American Association for the Advancement of Science
Committee on the Place of Science in Education

December 29, 1933

Morning Session

9:30 A.M.

Room 2-190

Massachusetts Institute of Technology
Cambridge, Mass.

Presiding Officer: E. S. Obourn, Teacher of Science,
John Burroughs School, St. Louis, Missouri

Remarks on the Committee on the Place of Science in Education and its Function in Organizing the Program of this Conference. Otis W. Caldwell, Chairman of the A.A.A.S. Committee on the Place of Science in Education.

Reports of Experiments in Teaching Scientific Method. Ira C. Davis, University High School, School of Education, University of Wisconsin, Madison, Wisconsin.

Discussion led by Homer W. LeSourd, Head of Science Department, Milton Academy, Milton, Massachusetts; and Christina B. Locke, Teacher of Science, Dorchester High School for Girls, Boston, Massachusetts.

Open discussion.

The Science Teacher's Scholarship and Professional Training. Wilhelm Segerblom, Head of the Department of Chemistry, Phillips Exeter Academy, Exeter, New Hampshire.

Discussion led by Ralph C. Bean, Head of the Science Department, Girls' High School, Boston, Massachusetts, and President, New England Biological Association; and Francis T. Spaulding, Department of Secondary Education, Graduate School of Education, Harvard University, Cambridge, Massachusetts.

Open discussion.

Experiments With High School Science Clubs. Morris Meister, Chairman of the Department of Physical Science, Haaren High School, New York, New York.

Science Clubs in Relation to State Academies of Science. S. W. Bilsing, Department of Entomology, Agricultural and Mechanical College of Texas, College Station, Texas.

Discussion of preceding papers on science clubs led by Pauline Beery Mack, Editor, Science Leaflets, State College of Pennsylvania, State College, Pennsylvania.

LUNCHEON

12:30 P.M.

Massachusetts Institute of Technology
Walker Memorial—North Dining Room
(Luncheon at $1.00 per person)

Presiding Officer: Jerome Isenbarger, Teacher of Biology, Chicago Public High Schools, Chicago, Illinois

Some Reactions of Science Upon Those Who Study It. John C. Merriam, President, Carnegie Institution of Washington, Washington, D. C.

AFTERNOON SESSION

2:00 P.M.

Room 2–190

Massachusetts Institute of Technology

Presiding Officer: Harry A. Carpenter, Specialist in Science, Rochester Public Schools, Rochester, New York

The Work of the Central Association of Science and Mathematics Teachers· William Frederick Roecker, Chairman of the Science Department, Boys' Technical High School, Milwaukee, Wisconsin.

Types of Useful Organizations of Science Teachers. W. L. Eikenberry, Head of Science Department, State Teachers College, Trenton, New Jersey, and President, Association of Science Teachers of the Middle States and Maryland.

Are Further Organizations of Science Teachers Needed? An open discussion.